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Taxpayers' responsiveness to tax rate changes and implications for the cost of taxation in Sweden

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Abstract Historically, labor supply elasticities have been used to evaluate tax policy and predict tax revenue effects. They are likely to underestimate taxpayers' response to tax rate changes, and hence to underestimate changes in potential tax revenues, however, because they measure only how taxpayers alter hours worked. Taxpayers can also respond to tax rate changes by altering, for instance, their work effort and form of compensation. An alternative measure that accounts for these responses as well as hours worked is the elasticity of taxable income. This paper estimates the elasticity of earned taxable income for Swedish taxpayers using two different approaches and a number of control variables and the 1990/1991 tax reform as a "natural experiment". The preferred elasticity estimates fall in the range of 0.4–0.5, comparable with recent estimates for the U.S. and larger than most of the labor supply elasticity estimates used to evaluate tax policy in Scandinavia previously, which suggests that deadweight losses are two to three times higher than previously thought.

Keywords Tax reform · Elasticity of taxable income · Deadweight loss

JEL Classification H21 · H24 · H31 · J22

1 Introduction

Economists have long known that individuals alter their economic behavior in response to taxation. Not only may individuals choose to work less (or more) when labor tax rates are higher, but they may also renegotiate the form in which they are compensated. For example, individuals may shift ordinary income to unearned income, and when

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tax rates are high they may be willing to take out more compensation in the form of fringe benefits or even to engage in outright tax evasion. Moreover, high tax rates even increase incentives to shift consumption towards such tax-preferred goods and services as housing, which can further lead to efficiency (deadweight) losses.

The implications of these distortions are important. If taxpayers reduce their reported incomes in response to higher tax rates, for instance, then policies aimed at raising additional tax revenues will be less effective than anticipated. Indeed, if taxpayers are extremely responsive to changes in tax rates and go to great lengths to rearrange the way they earn and receive income, the welfare cost of higher tax rates could be large relative to the tax revenues collected (Feldstein, 1995).

Economists have attempted to estimate the distortions created by labor income taxes going back to Harberger's seminal 1964 paper on deadweight loss (Harberger, 1964). Until the mid 1990s, attention was focused primarily on labor supply, and the typical low labor supply elasticity estimates implied that the deadweight loss associated with income taxes was relatively modest. Indeed, Harberger estimated that the deadweight loss associated with using a labor tax rather than a lump-sum tax was only about 2.5% in the U.S. (Harberger, 1964). Studies in the 1980's, moreover, found the extra costs of raising a dollar of public funds to be between 7 and 21 cents (Stuart, 1984; Ballard, Shoven, and Whalley, 1985; Browning, 1987).

These estimates may underestimate the true deadweight loss, however, because they ignore the effect of higher income tax rates on tax avoidance through changes in the form of compensation (e.g., between earned income and fringe benefits or between earned and unearned income), through changes in the pattern of consumption and savings (e.g., tax-favored consumption), and through changes in work effort (Feldstein, 1995). The elasticity of taxable income, which accounts explicitly for tax avoidance and implicitly for exclusions and deductions, has consequently received considerable recent attention (Feldstein, 1995; Carroll, 1998; Moffitt and Wilhelm, 1998; Slemrod, 1998; Auten and Carroll, 1999; Gruber and Saez, 2002). Predictably, estimates of the elasticity of taxable income have typically been higher than comparable labor supply elasticities, implying greater deadweight loss.

As one of the world's most heavily taxed countries, it is useful to estimate the elasticity of taxable income in Sweden as well. If Swedish taxpayers are less responsive than others—notably U.S. taxpayers who face much lower marginal tax rates—it will be relatively less costly to finance the public sector, which may go a long way in explaining the large size of government in Sweden. Moreover, it would also lend support to the conjecture that more egalitarian societies have lower compensated elasticities of taxable income (Slemrod and Kopczuk, 2002). An estimate of the elasticity of taxable income is obviously also important to Swedish policy makers and taxpayer advocates as they evaluate alternative tax policies and predict tax revenue effects. The most recent estimates of the income tax deadweight loss date back to studies in the 1980s (Hansson, 1984; Hansson and Stuart, 1985), and are based on labor supply elasticities rather than the elasticity of taxable income.

This paper examines the responsiveness of taxable earned income to changes in tax rates in Sweden using a rich data set of more than 80,000 individuals. Controlling for a large number of non-tax factors, including age, location, education, marital status, number of children, and changing macroeconomic environment, my estimates range from 0.3 to 0.8 and cluster around 0.4–0.5. These are considerably higher than the labor

supply elasticity estimates that have been used previously to calculate the deadweight loss of labor income taxes in Sweden. Corresponding estimates of deadweight loss were considerably larger than previously thought.

The following section summarizes some of the key findings from earlier studies. Section 3 presents estimates of elasticities of taxable earned income in Sweden, while Section 4 discusses the results. Section 5 estimates the deadweight loss based on elasticities of taxable earned income and Section 6 concludes the paper.

2 Earlier studies of the elasticity of taxable income

Lindsey (1987) was first to estimate the overall responsiveness of individuals to income taxes using tax reforms as a natural experiment to identify model parameters. Specifically, he used a series of cross-sections of U.S. taxpayer data to estimate the counterfactual distribution of earnings that would have existed in 1982 had the Economic Reform Tax Act of 1981 (ERTA 81)—which significantly reduced the marginal tax rates at high levels of income—not occurred. He found an elasticity of taxable income of between 1.6 and 1.8. A major statistical shortcoming of this approach, however, was the use of a synthetic panel of similarly situated taxpayers, which requires the strong assumption that taxpayers are in the same relative position in the income distribution both before and after the tax reform (Auten and Carroll, 1999).

Feldstein (1995) addressed this problem by using data covering the same individuals before and after the U.S. Tax Reform Act of 1986 (TRA 86), which further decreased marginal tax rates for high-income earners. Specifically, the differences-in-differences approach was used to compare changes in household taxable earned income for households with low versus households with high pre-reform marginal tax rates, where the latter benefited disproportionally from the TRA 86. The resulting elasticities ranged between 1.10 and 3.05.

Moffitt and Wilhelm (1998), using an instrumental variables approach with a number of identifying variables since the marginal tax rate is jointly determined with the amount of income reported, found that the large elasticities estimated by Feldstein (1995) were a result of focusing on the extreme upper tail of the income distribution. When including a wider range of incomes, they estimated elasticities of adjusted gross income between 0.16 and 0.97 based on alternative instrumental variables (excluding specifications where the instrument was statistically insignificant in the first-stage regression). The range narrowed considerably when mean-reversion—i.e., a tendency for a temporarily high income to be followed by a lower income and vice versa—was taken into account using pre-reform taxable income.

Carroll (1998) and Auten and Carroll (1999) also used the instrumental variables approach to identify the effect of income taxes on household income, but their instruments were based on constructed synthetic marginal tax rates. Compared to earlier studies, they were also able to account for more potentially confounding factors. Carroll (1998) found an elasticity of taxable income of 0.4 using the tax increases of 1990 and 1993 and Auten and Carroll (1999) found elasticities of reported income and taxable income of approximately 0.6 and 0.5, respectively, using the 1986 tax reform.

Gruber and Saez (2002) analyzed long-term state and federal tax data using the instrument variables approach and found an elasticity of 0.4, though there were important

differences by income. More recently, Saez (2004) estimated an elasticity of reported income of 0.4 for married individuals using "bracket creep" as a source of variation in marginal tax rates.

While most of the previous work has focused on U.S. tax reforms, there are a number of studies from other countries. Using the same approach as Auten and Carroll (1999), Sillamaa and Veall (2000) found an elasticity of taxable income of about 0.25 in Canada based on an unusually large tax reform in 1988. Likewise, Aarbu and Thoresen (2001) estimated the responsiveness of Norwegian taxpayers to income tax rates using the Norwegian tax reform of 1992 and found substantially smaller elasticities than most studies in the U.S., ranging from −0.03 to 0.2 when controlling for mean reversion. Finally, in an unpublished study, Selèn (2002) found an elasticity of taxable earned income for males in Sweden, ranging between 0.14 and 0.4, though there were limited means to control for non-tax factors and the conversion to a dual tax system.

3 Estimating the elasticity of taxable earned income in Sweden

3.1 The Swedish tax reform of 1990/1991

Prior to 1990, the Swedish tax system was complicated and was characterized by high marginal tax rates combined with extensive deduction possibilities that encouraged widespread tax planning. Indeed, high-income earners were often able to report little or no taxable income. In 1990/1991, Sweden implemented a major national tax reform which increased the uniformity of treatment of different forms of compensation, consumption, and savings; decreased marginal tax rates; and broadened the tax base by reducing deductions and exclusions. Specifically, value added taxes were standardized across goods and services, and tax rates on different forms of savings were equalized; many deductions and exemptions for capital income were eliminated; and the five-bracket national tax system ranging from 0 to 42% was replaced with a two-bracket national tax system with 0 and 20% marginal tax rates (local tax rates were basically unchanged at about 30%). Following the reform, thus, most taxpayers enjoyed a lower marginal tax rate (see Fig. 1), even if high-income earners benefited disproportionally more.

The reform also included a shift to a dual tax system, in which unearned income was separated from earned income and taxed at a flat 30% rate. For most high-income earners, thus, the marginal tax rate on unearned income suddenly became lower than on earned income, providing an incentive to shift from earned to unearned income.

The reform was intended to be distribution- and revenue-neutral. The effect of the decrease in the tax rates was to be offset by reduced allowances and restrictions on deductions and exemptions, by increases in consumption taxes, and through dynamic effects from lower marginal tax rates on labor and capital. To make the reform distributionally neutral, low-income earners were granted deductions that initially increased with taxable income (see Fig. 1) and more generous housing and child allowances. Unfortunately, the timing of the reform coincided with a serious macroeconomic weakening, so the tax reform was ultimately not revenue neutral over the short run. The reform was more successful in achieving distributional neutrality, however, and

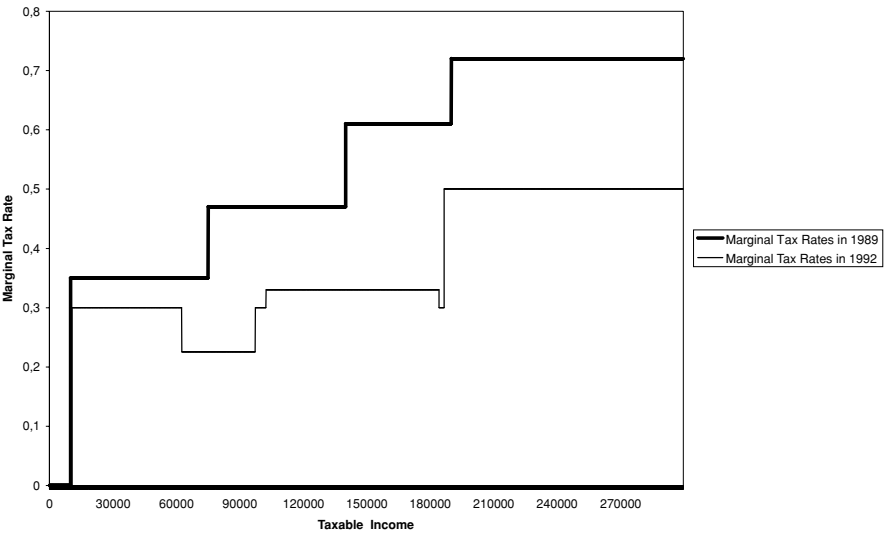

Fig. 1 Marginal tax rates in 1989 and 1992 as a function of taxable income (in nominal SEK)

redistribution appears to have been as large after as before the reform (Agell, Englund, and Södersten, 1995). Because many of the benefits accrued to families with children, however, low-income families without children may have been adversely affected.

3.2 Data

I analyze data from LINDA, a large panel data set of over 100,000 individuals and their household members selected to be representative of the Swedish population (SCB, 2003). The data are compiled from various official sources, including the income and wealth registers and population census data, and are a rich source of reliable measurements of income, taxes, and wealth, as well as demographic information (see Appendix for summary statistics).

I compare data from 1989 with data from 1992, 1 year before and 2 years after the 1990/1991 tax reform, which provides time for taxpayers to respond to the lower marginal tax rates and yet ensures that a large number of taxpayers have valid data both years. Moreover, the time span is short enough to ensure that many non-tax factors affecting taxable income, for example jobs, and job experience, did not change substantially for most taxpayers.

To minimize the effects of college attendance and retirement, I restrict the sample to working individuals between 25 and 60 years of age in 1989 who had positive taxable income in both 1989 and 1992. In addition, I restrict the sample to individuals with unchanged marital status and family size (number of children) to eliminate any effects these changes may have had on income. There are 82,670 individuals that meet these conditions and have valid data on a number of life-cycle dummies. There are 81,995 observations that additionally had valid education, income shifting, and macroeconomic vulnerability data as well.

3.3 Econometric approach

The Swedish tax reform of 1990/1991 provided, in many respects, a "natural experiment" with which to identify the responsiveness of Swedish taxpayers to changes in marginal tax rates. Specifically, by comparing pre- and post-reform taxable earned income for a panel of individuals, the elasticity of taxable earned income with respect to the net-of-tax rate (i.e., one minus the tax rate) can be identified, with the variation occurring between individuals in different tax brackets (for whom the reform had different implications).

Following Aarbu and Thoresen (2001), I estimate the elasticity of taxable earned income using two different estimation strategies. First, I use the differences-in-differences approach proposed by Feldstein (1995), in which *changes* in a group of high-income taxpayers' taxable earned income (experiencing a large decrease in their marginal tax rate) were compared to *changes* in taxable earned income of low-income taxpayers (who experienced a much smaller decrease in their marginal tax rate), but modified to control econometrically for a number of potentially confounding factors. Since even individuals within the same tax bracket display substantial heterogeneity, controlling for individual-specific factors may mitigate a host of potential biases.

Moffitt and Wilhelm (1998) have shown that this differences-in-differences approach is equivalent to two-stage least squares regression, where the instruments are dummy variables capturing the pre-reform marginal tax rate groupings (i.e., control versus treatment). I estimate the model using this instrumental variables approach because it provides a natural way to control for the above mentioned potentially confounding individual-specific factors. Operationally, I split taxpayers into those who faced the top national marginal tax rate of 42% and those who faced lower marginal rates. Effectively, this implies a first stage regression where the net-of-tax rate is regressed against this marginal tax rate dummy and a predicted value is fitted and a second stage where the change in taxable earned income is regressed on the predicted value and (unlike in Feldstein (1995)) other control variables.

Feldstein's approach has been criticized heavily, however, primarily because income growth has been heterogenous in the U.S. (Goolsbee, 1998). Differential time trends that are not explicitly controlled for do not difference away neatly and can lead to contaminated estimates. These concerns may be less applicable for Sweden where the income distribution is relatively compressed, however, and the regression-based approach does make it possible to control at least crudely for macroeconomic shocks as well as other individual-specific factors. Nevertheless, there is at least some evidence that economic opportunities changed differentially for different income groups in Sweden in the 1980s and 1990s (Gustafsson and Palmer, 2002), so I estimate the model using a second approach as well (which may provide an indication of stability of the results).

The second approach, following (Auten and Carroll, 1999), uses the instrumental variables approach in a different way to control for endogeneity. Specifically, I instrument the endogenous differences in the net-of-tax rate with the exogenous difference in a "synthetic" net-of-tax rate. This synthetic difference is defined by the actual net-of-tax rate prior to the reform and the post-reform tax rate corresponding to pre-reform income (inflated to 1992 values) converted to taxable earned income using post-reform rules. Intuitively, the instrument eliminates changes in income from changes in the

net-of-tax rate, hence leaving only the effect of the exogenous statutory change in the tax rate. Effectively, the first stage regresses the change in the actual net-of-tax rate on the change in the synthetic net-of-tax rate and the other exogenous variables, and then computes the predicted values. The second stage regresses the difference in taxable earned income on this predicted value and the other regressors.

3.3.1 Dependent variable

The dependent variable is the growth of taxable earned income between 1989 and 1992, i.e., the difference in the natural logarithms of taxable earned income in 1992 and in 1989. Since my focus is on the responsiveness of taxable earned income to *changes in marginal tax rates*, I eliminate the effects of the broadening of the tax base by converting 1989 taxable income to correspond to the 1992 tax rules using data on a host of newly disallowed deductions, among other things fringe benefits, and corrections for inflation and real wage increases. Similarly, I control for the switch to a dual tax system by subtracting unearned income from 1989 taxable income.

3.3.2 Regressors

In addition to the marginal tax rate, taxable earned income depends on numerous factors that are at least partly within the taxpayers' control (for instance, hours worked, forms of compensation, consumption and savings, and tax avoidance and evasion) and others that are not (e.g. business cycles, changing interest rates, demographic changes, and industrial shifts). In addition to the difference in the natural logarithm of the net-of-tax rate,[1] thus, a number of other explanatory variables likely to influence the change in taxable earned income are included. Education is represented by dummy variables corresponding to high school degree, college degree, and graduate degree. Life-cycle factors are represented by age, a dummy for married, number of children younger than 16 years of age, and unmarried and younger than 28 years of age. Dummies for residence in each of Sweden's 24 regions as well as residence in one of the major cities in Sweden (Stockholm, Gothenburg, and Malmö) are also included.

Following (Moffitt and Wilhelm, 1998) and others, I also include the natural logarithm of taxable earned income in the base year (1989) to control for mean reversion, the tendency for transitory increases in income prior to the reform to be followed by decreases in the following years and vice versa. Failure to control for mean reversion generally induces correlation between pre-reform income and the regression error when the unobserved determinants of behavior are also affected by the transitory factors.

A consequence of the tax reform was a gap between tax rates on earned and unearned income, providing incentives for income shifting. Since the tax rate difference is endogenously determined with taxable income in 1992, I follow Aarbu and Thoresen's (2001) approach and construct an exogenous proxy, the difference between 1989 income adjusted to 1992 levels by real wage growth in the period and the actual 1989 tax rate gap (0).

[1] While the actual marginal tax rates are not included in the data set, they can easily be calculated with the information provided in the data. The tax rate includes national and local taxes.

Because the post-reform economic downturn likely affected taxable earned income in 1992, and may very well have affected different income groups differently, I include a proxy for each individual's vulnerability to macroeconomic factors, namely interest burden. To ensure that this proxy is exogenous, I use the difference in real interest rates between 1992 and 1989 multiplied by 1989 debt.

3.4 Results

Results of the two-stage least squares regressions with the full sample are presented in Table 1.[2] The regressions reported in columns 1(a) and 1(b) control only for the net-of-tax rate and mean reversion. The differences-in-differences net-of-tax rate elasticity is 0.82 and the synthetic tax elasticity is 0.37. Both are statistically significant at high levels of confidence. The coefficient of 1989 income, which captures mean reversion, is negative and significant (both economically and statistically) in each regression.

[Numbers shown in parenthesis are *t*-values.
[a]Also include dummies for region.]

The estimates in columns 2(a) and 2(b) include additional life-cycle factors. The elasticity estimates are little changed even though each of the life-cycle factors is statistically significant. Age and the dummy for unmarried taxpayers under the age of 28 years have negative and statistically significant effects on the growth of taxable earned income. Being married and having children under the age of 16, on the other hand, have significant, positive effects on the growth of taxable earned income.

Columns 3(a) and 3(b) control additionally for income shifting related to the different tax rates on earned and unearned income, changes in the macroeconomic environment, residence in Stockholm or another large city, geographic region, and education. These controls sizably reduce the net-of-tax rate elasticity of taxable earned income in the differences-in-differences specification to 0.57, largely due to the inclusion of education. Their importance was more limited under the synthetic tax approach, where the elasticity increased to 0.43. Interestingly, the two estimates converge when more control variables were included.

Surprisingly, the income shifting variable has a positive and statistically significant coefficient, though the magnitude is not economically significant (a unit increase in the gap, or 357%, increases taxable earned income by 0.35%). Similarly, the macroeconomic environment has little impact on taxable earned income. Residing in a large city and in Stockholm does not have a significant impact on the growth of taxable earned income, though a number of regional dummies (not shown) have a large and statistically significant impact. As expected, education has a positive and statistically significant impact on the growth of taxable earned income, with the effect increasing for each additional degree earned.

Even though a substantial number of confounding factors have been controlled for, there may still be considerable heterogeneity in the elasticity of taxable earned income. For instance, it is well known that male labor supply is generally less responsive to tax rate changes than female labor supply (Ashenfelter and Layard, 1986). To

[2] The instruments—pre-reform marginal tax rate dummies and synthetic tax rate differences, respectively—were statistically significant with high degrees of confidence in the various first stage regressions and the R^2 values ranged between 0.42 and 0.60.

Table 1 Estimation of net-of-tax rate elasticity of taxable earned income

	(1a) D-in-D	(1b) Synt Tax	(2a) D-in-D	(2b) Synt Tax	(3a) D-in-D[a]	(3b) Synt Tax[a]
Net-of-tax rate	0.824 (31.57)	0.372 (22.38)	0.840 (32.27)	0.408 (24.23)	0.570 (23.47)	0.426 (26.31)
Log of pre-reform income	−0.502 (−98.97)	−0.432 (−110.68)	−0.494 (−98.80)	−0.429 (−109.78)	−0.507(−104.28)	−0.485 (−122.20)
Age			−0.005 (−20.02)	−0.004 (−18.10)	−0.002 (−8.55)	−0.002 (−7.80)
Married			0.0488 (10.27)	0.039 (8.57)	0.038 (8.34)	0.035 (7.82)
Children			0.011 (4.02)	0.007 (2.62)	−0.006 (−2.25)	−0.007 (−2.76)
Unmarried under 28 years			−0.251 (−4.82)	−0.231 (−4.62)	−0.184 (−3.72)	−0.179 (−3.68)
Income shifting					0.356 (28.61)	0.354 (28.82)
Macro economy					0.0002 (12.64)	0.0001 (12.23)
Big city					−0.015 (−1.64)	−0.011 (−1.19)
Stockholm					0.015 (1.24)	0.012 (1.00)
High school degree					0.060 (13.78)	0.061 (14.05)
College degree					0.235 (45.14)	0.234 (45.61)
Graduate degree					0.374 (16.27)	0.380 (16.75)
Constant	3.392 (107.81)	3.004 (117.22)	3.503 (107.48)	3.124 (116.73)	3.317 (87.14)	3.188 (93.52)
N	82,670	82,670	82,670	82,670	81,995	81,995

Table 2 Estimation of net-of-tax rate elasticity of taxable earned income on different subgroups[a]

	(1a) D-in-D men	(1b) Synt tax men	(2a) D-in-D women	(2b) Synt tax women	(3a) D-in-D low educ	(3b) Synt tax low educ	(4a) D-in-D high educ	(4b) Synt Tax high educ
Net-of-tax rate	0.469 (16.85)	0.286 (14.28)	0.474 (9.86)	0.759 (27.64)	0.403 (12.73)	0.410 (21.12)	0.939 (23.71)	0.496 (16.79)
Log of pre-reform income	−0.503 (−73.89)	−0.471 (−80.92)	−0.562 (−69.76)	−0.602 (−101.68)	−0.433 (−72.50)	−0.434 (−93.20)	−0.683 (−76.12)	−0.613 (−79.93)
Age	−0.002 (−5.32)	−0.001 (−4.38)	−0.001 (−4.63)	−0.002 (−5.24)	−0.002 (−6.90)	−0.002 (−6.98)	−0.002 (−3.34)	−0.0009 (−1.70)
Married	0.106 (15.11)	0.100 (14.62)	−0.023 (−3.97)	−0.019 (−3.22)	0.030 (6.09)	0.030 (6.15)	0.071 (6.59)	0.060 (5.95)
Children	−0.011 (−2.93)	−0.014 (−3.78)	−0.007 (−1.99)	−0.005 (−1.50)	−0.0005 (−0.17)	−0.0004 (−0.15)	−0.015 (−2.95)	−0.017 (−3.41)
Unmarried under 28 years	0.040 (0.48)	0.040 (0.48)	−0.292 (−5.00)	−0.312 (−5.24)	−0.155 (−2.79)	−0.155 (−2.79)	−0.321 (−3.00)	−0.261 (−2.59)
Income shifting	0.295 (16.92)	0.290 (17.01)	0.235 (13.38)	0.234 (13.09)	0.295 (20.94)	0.295 (20.94)	0.541 (20.57)	0.538 (21.67)
Macro economy	0.0001 (7.63)	0.0001 (7.14)	0.0002 (3.92)	0.0002 (3.76)	0.0001 (10.07)	0.0001 (10.13)	0.0003 (7.47)	0.0002 (6.81)
Big city	−0.031 (−2.38)	−0.024 (−1.93)	0.019 (1.51)	0.012 (0.92)	0.004 (0.34)	0.003 (0.32)	−0.074 (−3.62)	−0.056 (−2.89)
Stockholm	0.012 (0.71)	0.008 (0.49)	−0.0003 (−0.02)	0.006 (0.33)	−0.010 (−0.73)	−0.010 (−0.72)	0.085 (3.31)	0.071 (2.93)
High school degree	0.069 (11.51)	0.068 (11.58)	0.073 (11.83)	0.071 (11.25)	0.057 (13.46)	0.057 (13.45)		
College degree	0.254 (34.60)	0.251 (34.95)	0.258 (35.95)	0.257 (35.29)				
Graduate degree	0.333 (12.52)	0.339 (13.03)	0.474 (10.43)	0.466 (10.09)			0.174 (6.79)	0.191 (7.89)
Constant	3.354 (62.31)	3.158 (64.60)	3.670 (63.06)	3.894 (78.08)	2.840 (64.13)	2.846 (73.34)	3.791 (43.93)	4.469 (56.69)
N	43,858	43,858	38,137	38,137	62,259	62,259	19,793	19,793

Numbers shown in parenthesis are *t*-values.

[a]All regressions include dummies for region.

investigate whether the same is true for taxable earned income in Sweden, I regress the change in taxable earned income on net-of-tax rate and the full size of control variables for men and women separately. The results are reported in columns 1(a) to 2(b) of Table 2. Interestingly, estimates of the net-of-tax rate elasticity of taxable earned income are identical for men and women under the differences-in-differences approach, but considerably smaller for males (0.29) than for females (0.76) under the synthetic tax rate approach. The other explanatory variables seem to affect men's and women's taxable earned income growth in different ways and to different degrees. For instance, perhaps consistent with popular belief, marriage affects men's taxable earned income growth positively but women's taxable earned income growth negatively. Being under the age of 28 and unmarried has a negative impact on women's taxable earned income growth but no significant effect on that of men's, perhaps reflecting that these women have entered their childbearing years.

Responsiveness to tax rate changes may also vary by education level. Columns 3(a) to 4(b) in Table 2 report results for taxpayers with low (high school degree or less) and high (more than high school degree) education, respectively. The net-of-tax rate elasticity of taxable earned income is higher for high-educated taxpayers, which is not surprising given that they are generally better equipped to shift income and often have more to gain from tax avoidance and tax evasion, though the difference is more modest under the synthetic tax approach. Living in Stockholm has a positive effect on taxable earned income for high-educated taxpayers while no significant effect on low-educated taxpayers (the opposite is true for residing in a big city). Having children under the age of 16, however, affects taxable earned income negatively for high-educated taxpayers, though it has no effect for low-educated taxpayers.

I also estimate subgroup net-of-tax rate elasticities for young versus old taxpayers and self-employed versus employed (results not shown). Younger taxpayers, with elasticity estimates of 0.79 using the differences-in-differences and 0.59 using the synthetic tax approach, were considerably more sensitive than older taxpayers, who had elasticity estimates of 0.31 under both approaches. Interestingly, self-employed were less sensitive than their not self-employed peers using the differences-in-differences approach (0.23 vs. 0.66) but more sensitive using the synthetic tax approach (0.71 vs. 0.36).

3.4.1 Sensitivity analysis

Despite an unusually rich data set, there are a number of inherent limitations in this analysis. To assess the robustness of my results to these limitations, I varied a number of key assumptions and re-estimated the model. The results are presented in Table 3.

First, in separating out the effect of changes in tax rates from changes in the definition of taxable income, the conversion of actual 1989 taxable earned income to the counterfactual taxable income that would have occurred under 1992 rules was imperfect. In particular, while data were available to mimic changes in deductions and benefit programs reasonably well, there are some important exceptions (particularly with valuing fringe and dependent benefits) so I re-estimated the model using the same average fraction of deductions to taxable earned income for taxpayers in 1989 as in 1992 (effectively increasing deductions in 1989). The elasticity estimates were little changed (0.54 and 0.38, respectively). Similarly, restricting the sample to "childless"

Table 3 Sensitivity analysis

		Net-of-tax rate elasticity	
	Sample size	D-in-D	Synt Tax
Baseline estimation	81,995	0.570 (23.47)	0.426 (26.31)
Increasing the tax base to correspond to 1992 deductions	81,995	0.543 (22.59)	0.381 (22.50)
Childless taxpayers	61,795	0.543 (18.82)	0.444 (23.01)
Taxpayers with no capital income both years	21,802	0.287 (6.36)	0.482 (17.96)
Elasticity of earned plus unearned income	81,995	0.543 (22.59)	0.381 (22.50)
Excluding taxpayers receiving transfer benefits in 1989 and 1992	78,341	0.539 (22.50)	0.380 (24.16)
Taxpayers with positive interest income	60,189	0.495 (19.71)	0.347 (20.33)
Taxpayers living in the same town	76,315	0.546 (22.05)	0.413 (25.16)
1989 and 1991 reference years	90,492	0.503 (25.02)	0.407 (28.06)
Taxpayers 30–55 years of age	60,511	0.484 (18.83)	0.341 (19.66)
Taxpayers living in the same town	76,315	0.546 (22.05)	0.413 (25.16)
Cut-off marginal tax rate 31%	81,995	0.664 (30.69)	n.a.

Numbers shown in parenthesis are *t*-values.
All regressions include the full set of control variables.

taxpayers (for whom converting dependent-related benefits exactly would be easiest) had a modest impact, decreasing the differences-in-differences estimate to 0.54 and increasing the synthetic tax estimate to 0.44.

Second, the transition from a single to a dual tax system uncoupled the marginal tax rates for earned and unearned income, which provided incentives to shift earned income. While I controlled for income-shifting using the labor-capital tax rate gap, I also investigated model robustness by re-estimating the model for roughly 20,000 individuals who had no capital income in both years. While the net-of-tax rate elasticity fell sharply to 0.29 using the differences-in-differences approach, it was unaffected using the synthetic tax approach. In addition, I estimated the model using a broader measure of income, taxable earned plus taxable unearned income. While these results should be compared carefully, net-of-tax rate elasticity estimates were well within the range of other estimates (0.56 and 0.39, respectively), suggesting that income shifting does not drive the results.

Third, to the extent that the recession occurring just after the reform took effect impacted different subgroups (in particular low vs. high earners) differently, the estimate of the net-of-tax rate elasticity may be confounded (particularly the differences-in-differences estimates which use earnings growth for low-income earners as the control). While macroeconomic vulnerability was included in the regressions it is unlikely to capture the entire impact. I assessed the extent of residual bias informally in three ways. First, I excluded individuals who received transfers in both 1989 and 1992, which reduced the estimated elasticities only modestly. Second, I estimated the model including only individuals with positive interest income, who were conceivably less vulnerable to the recession, which reduced the estimates to 0.49 and 0.35, respectively. Finally, vulnerability to economic slowdown was tightly linked to job tenure in Sweden at this time. Unfortunately job seniority was not included in the

data, but since job turnover was low in Sweden during this time period, it is probably correlated with age. Since older low earners were presumably less vulnerable to the downturn than younger low earners they may provide a better control group and, conversely, including younger workers may overstate true taxpayer responsiveness. As the smaller elasticity estimates for 40–60-year-olds (0.31 and 0.31) reported above likely also reflect some measure of true age-related differences, however, they may serve as a lower bound.

Finally, I assessed robustness to the general modeling assumptions used. First, using 1991 rather than 1992 as the end year decreased the elasticity estimates to 0.50 and 0.41 for the two approaches, respectively, likely because individuals had less time to adapt. Second, restricting the sample to 30–55-year-olds to further reduce the impact of education and retirement (and perhaps health) reduced the estimates to 0.48 and 0.34, respectively. Third, excluding approximately 5000 individuals who moved from one town to another (effectively introducing an additional change in the local tax rate) had only a marginal effect. In addition, decreasing the marginal tax rate cut-off for the control group in the differences-in-differences regressions to 31% resulted in a sizable increase in the elasticity estimate to 0.66.

4 Discussion

Using the "natural experiment" offered by the 1990/1991 tax reform and two different statistical techniques, I find that Swedish taxpayers are responsive to changes in marginal tax rates. Specifically, without controlling for anything other than mean reversion, the differences-in-differences estimate of the net-of-tax rate elasticity was 0.82 and the synthetic tax rate estimate was 0.37. These results were relatively unchanged by the addition of controls for age and family status, but they converged dramatically to 0.57 and 0.43, respectively, when a full set of control variables (and in particular education) was included, which was largely the consequence of the differences-in-differences estimate converging toward the more stable synthetic tax rate estimate.

The full model was relatively stable. Sensitivity analysis yielded estimates from approximately 0.29 to 0.66 for the differences-in-differences results (with a central tendency of about 0.5) and from approximately 0.34 to 0.44 for the synthetic tax approach (with a central tendency of about 0.4). There were interesting subgroup differences by statistical approach used. In particular, women were considerably more responsive than men, as they are in most studies of labor supply elasticity (Ashenfelter and Layard, 1986), using the synthetic tax approach but not the differences-in-differences approach. The differences-in-differences approach also gave the non-intuitive result that the self-employed (who have greater means to shift compensation) were less responsive than the not self-employed, while the synthetic tax approach yielded the opposite.

The convergence toward the synthetic tax rate estimates may be logical. The instruments used in the synthetic tax rate approach—the exogenous difference in the synthetic net-of-tax rate—are constructed to be (at least in principle) uncorrelated with the error term. The pre-reform marginal tax rate (and dummy variables formed from it) used in the differences-in-differences approach, however, may be a poor "instrument" especially when few control variables are included (Moffitt and Wilhelm,

1998). Indeed, it seems unlikely that the pre-reform marginal tax rates are uncorrelated with omitted factors embedded in the error term in my simpler regressions, in particular education, thus violating the requirements of a good instrument. The fact that the differences-in-differences estimates converge toward the perhaps more believable synthetic tax rate estimates when the full set of controls is included is reassuring.

Despite differences in income measure, I used taxable *earned* income while many others used taxable income or AGI, my estimates are comparable with those of many of the more recent U.S. studies, which are generally well below the earlier estimates of Lindsey (1987) and Feldstein (1995) among others. This suggests that the large public sector can probably not be explained by lower costs of raising tax revenues in Sweden. However, unlike Aarbu and Thoresen's (2001) elasticity estimates for Norway, my elasticity estimates conflict with the prediction that individuals in relatively egalitarian societies are less sensitive to tax rate changes in actual practice (Slemrod and Kopczuk, 2002).

My estimates for men, 0.29 and 0.47, are also slightly higher than Selèn's (2002) estimates for taxable earned income, which ranged from 0.14 to 0.40. Two important methodological differences may help explain the difference. First, unlike the current study Selèn was unable to separate the effects of tax rate changes from tax base changes. Second, Selèn lacked many of the control variables employed in the current study, though he did control for hours worked (unlike here). In addition, the sample of more than 40,000 males and nearly 40,000 females in the current study (versus 3700 males in Selèn (2002)), may have permitted greater precision in the estimates.

The estimated elasticities reported here must obviously be interpreted with care. First, tax reform is not a true experiment. While the government assigns the tax code, individuals are free to choose (simultaneously) both taxable income and the marginal tax rate. Neither is tax reform "natural", which implies that the assignment of taxpayers to groups treated differently may not be random. If members of different income groups, for example, have different attitudes towards changes in marginal tax rates, the resulting estimates may be biased. Unfortunately, this problem is not easily overcome with currently available data and methods.

Second, as pointed out by Auerbach and Slemrod (1997) and Goolsbee (1998), increases in taxable income may equally well reflect longer term trends in the economy, perhaps affecting income distribution, rather than the actual tax reform itself. The estimated elasticities would then, at least in part, be the result of spurious correlation. Saez (2004), by using "bracket-creep" as a source of variation in marginal tax rates, mitigates this problem by comparing individuals with very similar incomes (in the same tax bracket) and found elasticities close to other recent studies. In addition, Carroll (1998) obtained similar estimates of the elasticity of taxable income in a study comparing the relative responsiveness of high- and middle-income taxpayers to a tax rate *increase*. Taken together, this problem may be relatively limited even in the U.S. Because the income distribution is considerably more equal in Sweden, this concern may be even less serious in the current study.

Third, it is important to distinguish between permanent and transitory as well as short-run and long-run responses. If the tax reform was perceived as a transitory change, the short-run elasticity, as captured here, may greatly overestimate the response. The tax reform, however, was neither motivated nor implemented to be transitory. The long-run responses to permanent changes may involve changes in education,

occupation, and location, which might imply that the response estimates are actually an underestimate.

Fourth, as with most previous research, this study has largely neglected unearned income. If a consequence of the tax reform was a large shift from earned to unearned income, some of the loss in tax revenues on earned income will be compensated with higher tax revenues on unearned income. As Slemrod (1998) notes, "... the taxable income elasticity at best promises to deliver a measure of the efficiency cost of one particular way to raise revenues—via increasing marginal tax rates—and does not summarize the cost of expanding government."

5 Implications for the cost of taxation

While the elasticity estimates in this paper are slightly lower than the most recent estimates for the U.S., they are higher than most estimates of the *labor supply elasticity* in Sweden, which range from 0.08 to 0.3 for males and 0.1 to 0.79 for females (Blomquist and Hansson-Brusewitz, 1990; Aronsson and Palme, 1998). Because previous estimates of the deadweight loss of labor income taxes in Sweden are universally based on labor supply elasticities, this has important implications for tax policy evaluation. In particular, estimates of the deadweight loss due to labor taxation using labor supply elasticities may underestimate the true deadweight loss.

In order to remedy this possible underestimation, I re-estimate the marginal excess burden using Stuart's (1984) model to calculate the marginal excess burden. Specifically, the extra cost of raising an additional unit of tax revenues is calculated in a simple general equilibrium model with a single utility-maximizing household that allocates a fixed amount of time between a taxed and an untaxed sector. The model calculates the cost of raising public funds that are either redistributed in a lump-sum way or spent on government consumption. The marginal excess burden is calculated as the compensation required to equate the utility levels of the pre-tax-increase and the post-tax-increase divided by the change in tax revenues obtained.

I parameterize the model using Swedish data from 2001. A key input is the overall marginal tax rate on labor income (henceforth referred to as the marginal tax rate). The marginal tax rate is an average marginal tax rate for 2001 that includes income, payroll, and indirect taxation as well as income-indexed transfers since they all can be avoided if labor is shifted from taxed to untaxed use. The resulting tax rate is 69.4% (RSV, 2003; SCB, 2003) when all payroll contributions are considered taxes and 66.7% when two-thirds of payroll contributions are considered to be taxes. Other important variables for the model are number of hours worked in the economy (1333 per person between the age of 20 and 64), labor's share of the economy in the taxed and untaxed sector (0.746 for both sectors), and data on the amounts of tax revenues spent on public consumption (233 billion SEK) and transfers (487 billion SEK), respectively. For further details on how to parameterize the model see Stuart (1984).

In addition, compensated and uncompensated elasticities are required to parameterize the model. Stuart uses a compensated labor supply elasticity of 0.2 and an uncompensated elasticity of 0 for the US in his benchmark case. Earlier studies based on Swedish data have used compensated and uncompensated elasticities of 0.25 and 0.1, respectively (Hansson, 1984; Hansson and Stuart, 1985). In my benchmark case,

Table 4 Marginal excess burdens and marginal tax rate at which the Laffer curve peaks

	Marginal excess burden at		Laffer peak (t^*)
	$t = 69.4$	$t = 66.7$	$t^*(t = 69.4)/t^*(t = 66.7)$
$\eta_c = 0.25, \eta = 0.1$			
Spending on consumption	0.97	1.10	83/81
Spending on redistribution	1.44	1.45	81/80
$\eta_c = 0.4, \eta = 0$			
Spending on consumption	1.23	1.61	82/80
Spending on redistribution	2.16	2.40	79/78
$\eta_c = 0.4, \eta = 0.2$			
Spending on consumption	1.83	2.30	79/77
Spending on redistribution	2.98	2.98	76/75
$\eta_c = 0.5, \eta = 0.1$			
Spending on consumption	2.06	2.41	79/78
Spending on redistribution	3.68	3.28	76/76
$\eta_c = 0.5, \eta = 0.3$			
Spending on consumption	3.00	3.09	76/74
Spending on redistribution	4.63	4.52	74/73

I use compensated and uncompensated elasticities of 0.4 and 0.2, respectively.[3] I compare results using this elasticity pair to results obtained using traditional labor supply elasticities for Sweden.

Results from simulations where the marginal tax rate is increased in one-percentage-point increments are shown in Table 4. At the 69.4% marginal tax rate and with compensated and uncompensated elasticities of 0.25 and 0.1, respectively, the marginal excess burden of marginal tax revenues spent on consumption is 0.97 (i.e., each additional Swedish crown (SEK) spent on government consumption is efficient only if it generates benefits of at least 1.97 SEK). The corresponding marginal excess burden for additional public funds spent on redistribution is 1.44,[4] which is larger than the welfare cost of government consumption because tax revenues redistributed to taxpayers induce an income effect that increases the tendency for labor to abandon the taxed sector when tax rates increase. Table 4 also shows the tax rate at which the Laffer curve peaks, t^*, in this case at a tax rate of 83 and 81%, respectively. The total average excess burden is 22% at a tax rate of 69.4% (not shown).

The marginal excess burden increases when the compensated elasticity is increased to 0.4 and the uncompensated elasticity is 0 (that is, the income elasticity is 0.4). The marginal excess burden of an additional crown spent on government consumption increases to 1.23 while the marginal excess burden for additional spending on redistribution is now 2.16. The Laffer curve peaks at 82 and 79%, respectively, and the total average excess burden is around 33%.

[3] The estimate for the compensated elasticity of taxable income is derived using income elasticity estimates from Selèn (2002). Selèn found that the income elasticity generally range from 0.2 to 0.4.

[4] Estimates on marginal excess burden from Hansson and Stuart (1985), which are based on a slightly different model and data from 1969, are 0.69 and 1.29 at a 70% marginal tax rate when funds are spent on public consumption and redistributed, respectively.

Decreasing the income effect such that the uncompensated elasticity is 0.2 instead of 0 further increases the marginal excess burden. The marginal excess burden of additional tax revenues spent on government consumption is 1.83, while the marginal excess burden of additional tax revenues redistributed is 2.98. The Laffer curve now peaks at 79 and 76%, respectively, and the total average excess burden is around 36%.

Higher compensated elasticities increase the marginal excess burden further. When the compensated elasticity is 0.5 and the compensated elasticity 0.1, the marginal excess burdens of an additional SEK spent on government consumption and redistribution are 2.06 and 3.68 SEK, respectively. When the income elasticity is lowered to 0.2, resulting in a compensated elasticity of 0.3, the marginal excess burdens of an additional SEK spent on government consumption and redistributed are 3.00 and 4.63, respectively.

Because not all payroll contributions function as taxes, I re-evaluate the marginal excess burden at a tax rate of 67%, the prevailing marginal tax rate in 2001 if only two-thirds of payroll contributions are considered taxes. This does not change the estimates of marginal excess burden noticeably. For instance, with compensated and uncompensated elasticities of 0.4 and 0.2, respectively, the marginal excess burden of additional tax revenues redistributed is 2.98 SEK regardless of whether the marginal tax rate is 69 or 67%. Under other elasticity pairs the marginal excess burden is often higher when payroll contributions are not considered exclusively a tax, despite being evaluated at a lower marginal tax rate, because netting out part of the payroll contribution changes the average tax rate more than the marginal tax rate and, hence, increases tax progressivity.

To investigate how sensitive the results are to assumptions made, the marginal excess burden is re-estimated when additional tax revenues are redistributed using different values for some of the key parameters. The first row in Table 5 shows the marginal excess burden in the benchmark case. In the second row, I re-estimate the marginal excess burden assuming that payroll contributions are a fee to see how sensitive the results are to assumptions made about what fraction of payroll contributions is considered to be at tax. This lowers the marginal excess burden to 2.46 and the tax rate at which the Laffer curve peaks to 73%.

In the third row, I assess sensitivity to assumptions made about the number of hours worked in the economy. In the benchmark case, I use the number of hours worked per working-aged individual. An alternative is to use the number of hours worked per employee, which was 1643 hours in 2001. Using this higher number of working hours reduces the marginal excess burden to 2.46 and increases the peak of the Laffer curve to 77%.

Table 5 Sensitivity analysis

Assumptions	Marginal excess burden	Laffer peak (t^*)
Benchmark case, $t = 69.4$, $\eta_c = 0.4$, $\eta = 0.2$	2.98	76
Payroll contributions no tax ($t = 59.3$)	2.46	73
Working hours 1 643	2.46	77
Labor share in untaxed sector 0.95	2.98	76
Gov consumption = 133, Transfer = 588.6	2.99	76
Gov consumption = 333, Transfer = 388.6	2.68	76

Finally, I investigate sensitivity to assumptions made about labor share in the untaxed sector (row 4) and amounts of tax revenues spent on public consumption and transfers (rows 5 and 6), respectively. The results are robust, though marginal excess burden is higher when more is spent on redistribution.

These estimates of the cost of income taxation are two to three times higher than previous estimates based on labor supply elasticities. They should be interpreted with care, however, as the marginal excess burden model is, strictly speaking, designed for labor income (and hence the labor supply elasticity) and not taxable income (and hence the taxable income elasticity). If the marginal excess burden associated with changes in taxable income differs from the marginal excess burden of changes in labor supply, my results may either understate or overstate the true effect. For example, an individual may change the amount of income hidden but not the amount of labor income in response to a tax rate change, affecting tax revenues but not the amount required to compensate the individual for a change in utility, which will not give rise to a marginal excess burden in the model (other than compensating for lower government spending).[5] In this case, my estimates would likely overestimate the marginal excess burden.

One way to avoid this problem is to use a more disaggregated approach for estimating the deadweight loss. For example, Parry (2002) obtained the overall marginal excess burden by adding the marginal excess burden associated with tax-preferred consumption (such as medical insurance and owner-occupied housing) to the traditional marginal excess burden based on labor supply elasticities. Whereas I found a doubling to tripling of the marginal excess burden, Parry found that his approach doubled the estimates (though this varies considerably depending on assumptions). The disadvantage of using Parry's approach compared to taxable income elasticities, however, is that it requires information about several elasticities—all measured with uncertainty—and fails to include several forms of tax-preferred consumption as well as tax evasion, which suggests that marginal excess burden will be underestimated. A reasonable value may hence lie between two and three, consistent with most of my estimates.[6]

6 Conclusions

Using a large panel of Swedish taxpayers, I used the "natural experiment" approach to estimate taxpayer responsiveness to changes in their marginal tax rates enacted in 1990/1991. The taxpayers were relatively responsive, with estimates of the net-of-tax rate elasticity of taxable earned income clustering around 0.4–0.5. Taxpayer responsiveness was found to vary substantially across different subgroups. Males were less responsive than females, for instance, and younger are more responsive than older taxpayers. In addition, college-educated taxpayers were at least moderately more

[5] There is, however, a deadweight loss associated with the effort of tax planning.

[6] Hansson (2004) reports results from a simple partial equilibrium, but internally consistent, model of *total* excess burden based on these same Swedish taxable income elasticity estimates. Total excess burden estimates increased from 3 to 14% when the taxable income elasticity was used instead of labor supply elasticity and the Laffer curve peaked at approximately the same value as the current study.

responsive than non-college educated individuals. While there are a number of caveats, the concordance between these estimates and other estimates of the elasticity of taxable income in Sweden argue for updating the Swedish cost of public funds literature with these new, higher values. Crude updates based on Stuart's (1984) general equilibrium model indicate that the marginal excess burden is between two and three times larger when using these taxable earned income elasticities than when using traditional labor supply elasticities.

Appendix: Summary statistics

Variable	Mean	Standard deviation	*N*
Taxable income 1989	117623	84230	81,995
Taxable income 1992	155654	94350	81,995
Adjusted taxable income 1989	154880	106900	81,995
Labor income 1989	137770	71380	81,995
Labor income 1992	160750	102680	81,995
National tax rate 1989	18.9	10.3	81,995
National tax rate 1992	5.10	8.7	81,995
Total marginal tax rate 1989	49.8	10.3	81,995
Total marginal tax rate 1992	36.1	8.7	81,995
Age 1989	42.6	10.2	81,995
Married	0.54	0.50	81,995
Number of children under	0.45	0.87	81,995
Less than high-school degree	0.31	0.46	81,995
High-school degree	0.44	0.50	81,995
College degree	0.23	0.42	81,995
Graduate degree	0.006	0.08	81,995
Income shifting	0.28	0.16	81,995
Macroeconomy	16.6	132.4	81,995

Note: Summary statistics correspond to the observations included in the full regression.

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