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Estimating the elasticity of taxable income when earnings responses are sluggish

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Estimating the elasticity of taxable income when earnings responses are sluggish

Abstract:
Estimates of the elasticity of taxable income (ETI) is conventionally obtained by “stacking” three-year overlapping differences in the estimation. In effect, this means that the ETI estimate is an average of first-, second-, and third-year effects. The present paper draws attention to this implication and suggests that if there is gradual adjustment the analyst should rather estimate the ETI by a dynamic panel data model. When using Norwegian income tax return data for wage earners over a 14-year period (1995−2008) in the estimation, an ETI estimate of 0.15 is obtained from the dynamic specification, compared to 0.11 for the conventional approach. Importantly, the conventional approach fails to render a long-term elasticity estimate by increasing the time span of each difference.

Keywords: elasticity of taxable income, time frame, tax reform, earnings dynamics

JEL classification: H24, H31, J22

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Sammendrag

Elastisitet av skattepliktig inntekt (ETI) med hensyn på netto marginalskatt (1 minus marginalskatt) har blitt et nøkkelbegrep innen empirisk skatteforskning. Dette fordi ETI gir et samlet anslag for atferdseffekter som følge av skatteendringer, og kan gi et mål for det samfunnsøkonomiske effektivitetstapet ved inntektsbeskatning.

Den konvensjonelle empiriske metoden for å estimere ETI går ut på å analysere paneldata for rapportert inntekt over en periode med ulike eksogene endringer i skattesatser og innslagspunkt. For å tillate at atferdseffektene ikke nødvendigvis følger umiddelbart etter skatteendringen, spesifiserer man i den konvensjonelle metoden 3 års differanser. Men siden differansene "stables" overlappende sammen i en regresjon vil man i realiteten måle et gjennomsnitt av første års, andre års og tredje årseffekten av skatteendringene.

Denne studien viser at ved en gradvis tilpasning i skattepliktig inntekt, som for eksempel kan ventes ved såkalte reelle atferdseffekter (som endringer i arbeidstilbudet), bør man heller benytte et dynamisk rammeverk. Dette er illustrert ved å estimere ETI'er på norske registerdata for hele populasjonen av lønnstakere i alderen 25-62 år over en 14-års periode (1995-2008). Jeg finner ETI-estimater på 0,11 med den konvensjonelle metoden og på 0,15 på lang sikt (konvergerer etter omtrent fem år) med den dynamiske metoden. De dynamiske estimatene repliserer estimatet fra den konvensjonelle metoden når en tar hensyn til at den konvensjonelle metoden måler et gjennomsnitt av første, andre og tredje års effekten. Den konvensjonelle metoden er ikke i stand til å gi oss et langtidsestimat av effekten av skatteendringene, selv ved å variere lengden på tidsintervallene. Forskjellene i ETI estimatet fra den konvensjonelle og den dynamiske metoden er illustrert ved å beregne anslag for selvfinansieringsgraden ved et hypotetisk kutt i trinnskatten.

Hovedkonklusjonen i denne studien er at dersom det kan forventes at folk tilpasser arbeidsinntekten til endringer i skattesatsene gradvis heller enn umiddelbart etter endringer i skattesatsene, vil den konvensjonelle ETI metoden være dårlig egnet til å fange opp de endelige tilpasningene. Det betyr at en bør supplere med dynamiske metoder for å kunne gi et anslag på langsiktige ETI'er.

1 Introduction

The elasticity of taxable income (ETI) with respect to the net-of-tax rate has become a key parameter in empirical tax research, as it summarizes behavioral responses and represents a measure of the welfare costs of taxation (Saez et al., 2012). Several studies have contributed to how instruments can be constructed using the individuals' past income level over a tax reform period, and how one should address the accompanying challenges of mean reversion and heterogenous growth rates, see e.g. Auten and Carroll (1999), Gruber and Saez (2002) and Weber (2014).

The present paper draws attention to the assumption regarding the time span of behavioral effects of conventional ETI studies. Feldstein (1995) argued that one should apply a three-year time span to allow for the new tax schedule to be absorbed by the agents and to let them find their new optimum. Since then a practice has developed where analysts "stack" datasets by employing several three-year overlapping differences (including both reform- and non-reform periods), which has shown to be advantagous in order to control for mean reversion and heterogenous growth rates. The present paper emphasizes that stacking overlapping differences implies that the effects are not measured after three years, but instead one measures averages of the effects of the tax change after the first, second and third year.[1]

The main argument of the present study is that, given that one year is not enough to allow tax induced changes to materilize, the analyst should rather consider estimating the ETI by a dynamic approach. For instance, it can be expected that the conventional approach of obtaining ETI underestimates real earnings responses, which are likely to be slow. In the following this point is explored by employing panel data for the complete population of Norwegian wage earners over a period of multiple changes in the tax schedule (14 years). Estimated ETIs by the conventional approach (Weber, 2014) is compared to estimates when using a dynamic approach (Holmlund and Söderström, 2011).

The present study is the first analysis to compare (conceptually and empirically) the conventional and the dynamic approach of estimating the ETI. In particular it is demonstrated that a gradual earnings adjustment leads us from the conventional framework to a dynamic specification, and moreover, it is shown how results of the dynamic model can be tested against the results of the conventional approach. When applied to Norwegian wage earners, I find that the dynamic model reproduces the ETI of the conventional model, when acknowledging that the latter measures an average of the first, second and third year effect. But the estimate of the conventional approach (0.11) fails to reproduce the long-term effect (0.15),

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[1] Although both Bækgaard (2014) and Weber (2014) have noted this problem, the implication of the "stacking" practice is not clearly spelled out in the literature.

which is reached after about five years according to the dynamic model. Furthermore, it is demonstrated that the conventional approach does not produce a long-term elasticity estimate by simply extending the time span of each overlapping time difference to more than three years.

The paper is structured as follows: In Section 2 the ETI literature is reviewed, focusing on the time frame of responses, to place the present study in the context of existing literature. In Section 3 I conceptually compare the conventional and the dynamic framework for identifying income responses by tax reforms. Section 4 presents the tax schedule changes and the data used to estimate the two model specifications, and illustrates the methodological challenges that must be addressed to obtain unbiased ETI estimates. Estimation results for both the conventional and the dynamic specifications are reported in Section 5. In Section 6, I compare the results of the two methods and illustrate the fiscal implications of a hypothetical tax rate cut. Section 7 concludes.

2 The time frame of responses

ETI estimates have received considerable attention, as they hold the promise of summarizing all individual behavioral responses to tax rate changes, including labor supply responses (working hours), effort and occupational choice, as well as changes in tax avoidance or tax evasion (Saez et al., 2012).[2]

According to Slemrod's hierarchy of behavioral responses to taxation (Slemrod, 1995), real responses to taxation (such as altered labor supply behavior) are the least responsive compared to timing and avoidance responses. But as opposed to real responses, timing and avoidance responses may be only transitory, as discussed by e.g. Auerbach and Poterba (1988), Kreiner et al. (2016) and Doerrenberg et al. (2017).

When restricting attention to earnings or broad income, long-term responses can be expected to be larger than short-term responses because of sluggish behavioral adjustment, see e.g., Giertz (2010), Bækgaard (2014), Kleven and Schultz (2014), Neisser (2017) and Jongen and Stoel (2019).[3] Slow earnings responses is consistent with standard search-theoretic models of the labor market, in which it takes time for workers to find jobs and for firms to fill vacancies (Rogerson et al., 2005). Furthermore, optimization frictions, such as adjustment costs, (Chetty et al., 2011; Chetty, 2012; Gelber et al., 2019) and state dependence (Heckman, 1981; Johnson and Pencavel, 1984; Haan, 2010; Jia and Vattø, 2016) may prevent individuals

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[2] Under certain conditions it has been shown that ETI represents a sufficient statistic to assess the welfare costs of taxation (Feldstein, 1999; Chetty, 2009; Doerrenberg et al., 2017).

[3] However, as discussed by Giertz (2010) and Saez et al. (2012), and as I will return to, there are several methodological difficulties to obtaining long-term ETI estimates from the conventional approach.

from attaining their desired earnings level in the short-term. Moreover, it seems likely that it takes time for increased work effort, altered career choices, increased responsibility or more aggressive wage negotiations to translate into higher observed earnings.

A recent study by Gelber et al. (2019) finds that the long-term estimate of earnings responses among social security recipients is nearly twice as large as the short-term impact and suggest that the full adjustment takes about three years by using a local bunching approach.[4] Both Kleven and Schultz (2014) and Gelber et al. (2019) argue that if the full adjustment takes about three years, this represents a justification for the conventional ETI approach providing estimates of long-term effects. Thus, they do not acknowledge that estimates of the ETI are derived from "stacked" panels and therefore reflect an average of the first-, second- and third-year effects.

The present paper illustrates that the conventional ETI approach is likely to underestimate the effect of sluggish real responses, such as earnings. When effects materialize after more than a year, a way forward for the practioner is to employ a dynamic model. In the following sections I demonstrate the advantages of a dynamic approach by discussing effects on earnings responses. It is assumed that timing and avoidance responses can be ignored, as earnings are third-party reported in Norway.[5]

3 Identification of tax responses using tax reforms

In this section I present the conventional approach to obtain ETI estimates (Weber, 2014) and compare it to a dynamic specification (Holmlund and Söderström, 2011). In particular, I demonstrate that a gradual adjustment process leads us from the conventional framework to the dynamic specification, and how the findings of the dynamic model can be tested against the results of the conventional approach.

To start with, I present the conventional framework to estimate ETI, and highlight its shortcomings when the behavioral adjustments exceed one year. The economic model underlying the ETI literature is a simple extension of the traditional labor supply model, as shown by Feldstein (1999). Following the notation of Kleven and Schultz (2014), each taxpayer maximizes a utility function $u(c, z, \mathbf{x})$, where c is consumption, z is reported taxable income, and $\mathbf{x}$ is a vector of individual characteristics. The intuition is that it is not only hours worked that are negatively associated with individual utility, but also the effort needed to generate income, including training, occupational choice and tax sheltering activities.

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[4] Another branch of the literature, initiated by Saez (2010) derive ETI estimates based on bunching in the income distribution created by kink points in the tax schedule; see Chetty et al. (2011) and Bastani and Selin (2014).

[5] See Berg and Thoresen (2020) for an ETI estimate for Norwegian self-employed, for whom timing and avoidance responses (including income shifting) are more prevalent.

Utility is maximized subject to a budget constraint of the form $c = z - T(z) = (1-\tau) \cdot z + V$ where $T(.)$ is tax liability, $\tau = T'(.)$ is the marginal tax rate, $1-\tau$ is the net-of-tax rate and $V = \tau z - T(z)$ defines virtual income. Thus, the optimal "supply function", $s(.)$, of reported income can be described as, $z = s(1-\tau, V, \mathbf{x})$.

Following the conventional approach, a log-linear specification is adopted to estimate the elasticity of taxable income with respect to the net-of-tax rate, e: $\log(z_{it}) = e \cdot \log(1-\tau_{it}) + \beta_t \mathbf{x}_{it} + \alpha_t + \mu_i + \nu_{it}$, in which $\mathbf{x}_{it}$ refers to both time-variant individual characteristics whose effect is constant over time, and time-invariant characteristics whose effect may change over time.[6] The effect of time-invariant individual characteristics is subsumed in the individual fixed effect, μ_i, whereas a_t is a time-specific effect. The first-differenced version of the conventional specification is expressed as,

$$\Delta\log(z_{it}) = e \cdot \Delta\log(1-\tau_{it}) + \Delta\beta_t \mathbf{x}_{it} + \Delta\alpha_t + \Delta\nu_{it}. \tag{1}$$

Although there is an underlying theoretical assumption that the behavioral response to a tax rate change is immediate and permanent, Δ has typically been set to three-year differences $(t, t+3)$ to allow individuals some time to adjust, following the argumentation by Feldstein (1995). All available data on (overlapping) three-year differences are stacked in a single regression, following Gruber and Saez (2002) and Weber (2014).[7] An advantage of this approach (given that panels span periods both with and without tax reforms) is that one can use all available data to control for confounding effects without absorbing the tax rate variation created by each reform. A disadvantage is that when overlapping differences are used to identify e, the estimate is a combination of short-term and longer-term responses; as noted by Bækgaard (2014) and Weber (2014). For example, if a tax reform is implemented in year t_r, and no tax changes occurred in the years before or after the reform, then the estimated elasticity is an average of the following three components: first-year response including two years of anticipatory effects, first- and second-year responses including one year of anticipatory effects and the first-, second- and third-year responses (no anticipatory effects). In the following I ignore anticipatory effects,[8] so that the elasticity estimate is interpreted as

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[6] Effects of average tax changes, operationalized through virtual income, are often neglected in ETI studies. In a robustness test, I find small effects when controlling for virtual income, similar to the conclusions of Gruber and Saez (2002) and Kleven and Schultz (2014).

[7] For example, Gruber and Saez (2002) relate year 1982 to year 1979, year 1983 to year 1980,..., and year 1990 to year 1987. These nine differences are stacked to obtain a single dataset.

[8] If tax reforms are announced or anticipated in advance, individuals may respond (when possible) before the reform is implemented. For instance, Kreiner et al. (2016) document intertemporal income shifting when analyzing the effect of a payroll tax reform on monthly wage income in Denmark. As discussed by both Kreiner et al. (2016) and Doerrenberg et al. (2017), such transitory effects may influence short-term ETI estimates. In the present study, the ETI estimate of the dynamic specification reproduces the estimate of the conventional three-year panels. This suggests that anticipatory effects for wage earners are not substantial in

an average of the cumulative first-, second- and third-year effects. Thus, only if adjustment is immediate (within a year) the conventional ETI estimate reflects long-term effects of earnings responses.

Next, I demonstrate how a gradual earnings adjustment leads us from the conventional framework to a dynamic specification. A gradual earnings adjustment can be embodied in a simple theoretical model, where earnings are adjusted by some fraction of the difference between last period's earnings and the 'long-term' desired earnings level. I formulate this as,

$$\log(z_{it}) - \log(z_{it-1}) = \lambda(\log(z^*_{it}) - \log(z_{it-1})) \tag{2}$$

where z^*_{it} is long-term desired earnings and z_{it} is observed earnings, and $0 < \lambda < 1$. The parameter λ indicates the fraction of the difference between desired (latent) earnings, z^*_{it}, and actual earnings in the preceding year, z_{it-1}, which is reflected in current year's earnings as an increase (or decrease) on the previous year's earnings. If λ is close to 0, there is a slow speed of adjustment towards the long-term desired earnings level, and if λ is close to 1, there is a rapid adjustment process. For $\lambda = 1$ the standard specification is obtained, where current earnings equal desired earnings, $z_{it} = z^*_{it}$.

When incorporating gradual earnings adjustment given by Eq. (2) in the economic model of the conventional ETI literature, the desired earnings figure is given by $\log(z^*_{it}) = e \cdot \log(1-\tau_{it}) + \beta_t \mathbf{x}_{it} + \alpha_t + \mu_i + \nu_{it}$. The observed earnings dynamic over time is given by $\log(z_{it}) = (1-\lambda)\log(z_{it-1}) + \tilde{e}\log(1-\tau_{it}) + \tilde{\beta}_t \mathbf{x}_{it} + \tilde{a}_t + \tilde{\mu}_i + \tilde{\nu}_{it}$ where $(1-\lambda)\log(z_{it-1})$ signifies that there is an addition to income in period t due to the gradual earnings adjustment, not picked up by the conventional specification. The original estimates of e, β_t, a, μ, and ν are multiplied by λ, and thus denoted $\tilde{e}, \tilde{\beta}_t, \tilde{a}_t, \tilde{\mu}_i$, and $\tilde{\nu}_{it}$. In first-differenced form the model can be written as

$$\Delta\log(z_{it}) = p\Delta\log(z_{it-1}) + \tilde{e} \cdot \Delta\log(1-\tau_{it}) + \Delta\tilde{\beta}_t \mathbf{x}_{it} + \Delta\tilde{\alpha}_t + \Delta\tilde{\nu}_{it}, \tag{3}$$

where $\rho = 1 - \lambda$ measures the fractional adjustment in earnings each period and $\tilde{e} = \lambda e$ measures the short-term ETI. Now Δ refers to one-year differences $(t, t+1)$. Importantly, in the long-term (after earnings adjustment is completed) $\Delta\log(z_{it})$=$\Delta\log(z_{it-1})$, which implies that the long-term ETI is expressed by $e = \frac{\tilde{e}}{1-\rho}$.[9]

Subsequently, I describe the IV-approach of estimating ETI using the conventional model,

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the present analysis; see also Gelber et al. (2019) for a similar conclusion.

[9] It can be shown that a slightly more complex adjustment process given by $\log(z_{it}) - \log(z_{it-1}) = \lambda(\phi\log(z^*_{it}) + (1-\phi)\log(z^*_{it-1}) - \log(z_{it-1}))$ leads to a dynamic specification that also includes a lagged net-of-tax rate change, as estimated in Holmlund and Söderström (2011). Employing this model does not add to the principal results of the present paper.

given by Eq. (1), and using the dynamic model, given by Eq. (3), following Weber (2014) and Holmlund and Söderström (2011), respectively. For both specifications the marginal tax rate is endogenous to the choice of earnings (due to the progressive income tax schedule), which creates a correlation between $\Delta\log(1-\tau_{it})$ and the error term. The net-of-tax rate change given by $\Delta\log(1-\tau_t) = \log(1-\tau_{t+s}(z_{t+s})) - \log(1-\tau_t(z_t))$ is instrumented by $\Delta\log(1\text{-}\tau_t)^{synth} = \log(1-\tau_{t+s}(z_{t-1})) - \log(1-\tau_t(z_{t-1}))$, where $s = 3$ in the conventional approach (Weber, 2014) and $s = 1$ in the dynamic formulation (Holmlund and Söderström, 2011). In the following I will refer to these instruments as the synthetic net-of-tax rate change.[10] In the dynamic specification the lagged dependent variable is also endogenous and need to be instrumented. This is done, following Holmlund and Söderström (2011), by using information on the previous income level, as is standard in the literature on dynamic panel data models; see e.g. Anderson and Hsiao (1981).[11] Both the conventional and the dynamic specifications are estimated as two-stage least squares (2SLS) regressions.

Remember that a main contribution of the present paper is to show how the estimates of the dynamic model can be tested against the ETI estimate of the conventional approach, and to assess to which extent the conventional approach reflects the long-term effect. First note that the dynamic specification given by Eq. (3) is a generalization of the conventional formulation given by Eq. (1), when Δ refers to one-year differences and z_{it} refers to earnings. But as the conventional specification uses a wider time window (three-year differences), it partly captures the underlying earnings process without imposing the exact form of adjustment. To validate both models, e estimated by the conventional approach is first compared to an average of the first-, second- and third-year effects of the dynamic specification, given by $\tilde{e}$, $\tilde{e}(1+\rho)$, $\tilde{e}(1+\rho+\rho^2)$, respectively. Second, the extent to which the conventional approach is able to reflect the complete earnings adjustments is assessed by comparing the long-term estimate of the dynamic model, $\frac{\tilde{e}}{1-\rho}$, to e obtained from an estimation of a conventional model.

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[10] Using a socalled synthetic net-of-tax rate change to instrument the observed net-of-tax rate change was initiated by Auten and Carroll (1999) and Gruber and Saez (2002). However, they used income in the first year of each difference (base year income) to construct instruments. Weber (2014) and Holmlund and Söderström (2011) argue that lagged base year income should be used instead of base year income to construct synthetic tax rate changes in order to avoid the challenge of mean reversion. I therefore follow their approach of constructing instruments. A few studies propose using alternative net-of-tax rate instruments: Blomquist and Selin (2010) construct their instrument on the basis of the individuals' income period in the middle, Burns and Ziliak (2017) propose using Wald-type grouping instrumental variables and Matikka (2018) uses changes in flat municipal income tax rates to instrument for the net-of-tax rate change.

[11] As I will return to in Section 4.4, the synthetic tax rate instrument makes it necessary to control for a function of previous income also in the conventional specification.

4 Data and variation in the net-of-tax rate

4.1 Preliminaries

The empirical identification benefits from analyzing administrative data over a relatively long time period (1995−2008) with multiple tax rate changes. A methodological advantage of restricting attention to wage earners in the present analysis is that income fluctuations are thought to be relatively low among wage earners, which means that an individual's income in one year is a reasonable predictor of income for a later year.

This section proceeds as follows: Section 4.2 describes the tax schedule changes which creates exogenous variation in the synthetic tax rate changes. Section 4.3 describes the data in the empirical analysis and Section 4.4 illustrates the negative correlation between previous income levels and current income growth rates in periods without tax rate changes, which must be taken account of to provide unbiased ETI estimates.

4.2 Tax rate changes

Norway has a dual income tax system characterized by a flat tax on capital income and a step-wise progressive tax on labor income. During the period of consideration, earnings was taxed at a flat rate of 28 percent in addition to a social security contribution rate of 7.8 percent, and according to a two-tier surtax rate schedule. The income tax base for paying surtax rates was given by total labor income (no deduction possibilities). Multiple changes in the surtax schedule for labor income cause exogenous variation in tax rates over the period, described in Figure 1 (see also Table A.1 and Figure A.1 in the Appendix).

From 1995 to 1998, the two-tier surtax rates were 9.5 percent and 13.5 percent, respectively. Both tax brackets started at relatively low income levels, affecting respectively 49 and 35 percent of the wage earner sample. In 1999, the two-tier schedule was temporarily replaced by a single tax rate of 13.5 percent. Then a new two-tier schedule was introduced in the year 2000, with tax rates of 13.5 percent and 19.5 percent. However, the second rate was now only levied on very high levels of labor income, corresponding to the top 1−2 percent of the wage earner distribution. In the more comprehensive 2006 tax reform, the surtax rates were considerable reduced, to 9 and 12 percent, respectively. Brackets were again changed, such that the highest rate applied to 7−8 percent of the wage earners.[12]

Separate schedules for tax payers who reside in the north of Norway, and the existence of

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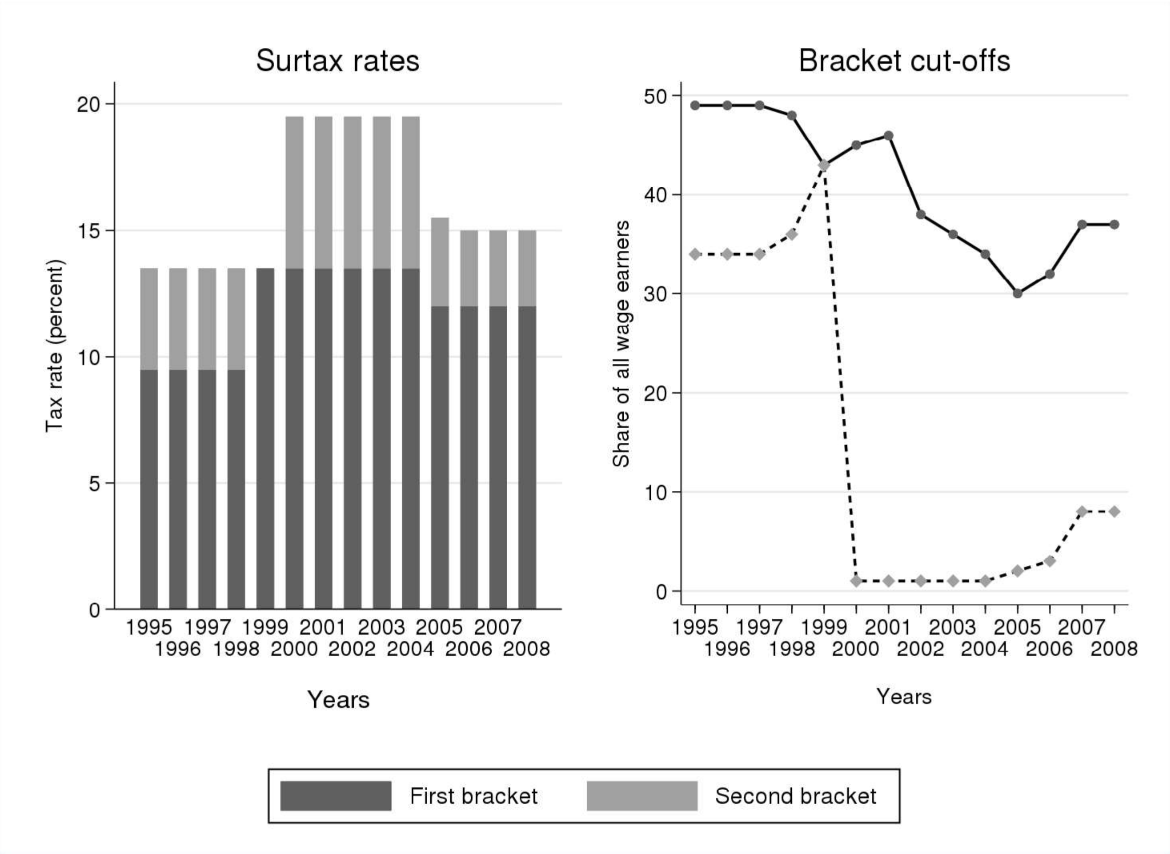
[12] The tax brackets are nominally adjusted by the Government each year. As the wage growth may differ from the tax bracket adjustment, this creates additional exogenous variation in the tax rate instruments, also within each of the three shorter periods, 1995-1998, 2000-2004 and 2006-2008. See Table A.1 in the Appendix for more details.

Figure 1. Exogeneous variation in surtax rates and bracket cut-offs for Norwegian wage earners, 1995−2008



Notes: The figure depicts the surtax rates and bracket adjustments over time. All these changes provide exogeneous tax variation for individuals with various income levels over time. More details on the nominal tax bracket adjustments are provided in Table A.1 in the Appendix.

a second tax class schedule for single parents and one-income families, provide additional exogenous variation across income levels (although I find that the results are robust to excluding these groups).[13] A further advantage for identification is that the highest income earners experienced both positive and negative changes in the tax rates.

Most of the tax schedule changes considered were announced shortly before they were implemented. However, the 2006 tax reform was announced in advance, and had strong timing effects on dividend payouts, as documented by Alstadsæter and Fjærli (2009). There are no clear signs of anticipatory effects in wage income, although the existence of such effects cannot be ruled out.

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[13] The bracket cut-offs for individuals or couples in the second tax class started at a slightly higher nominal level prior to 2005. After 2005 the two tax class schedules were equalized (apart from a higher standard deduction for the second tax class).

Table 1. Characteristics of the pooled wage earner sample 1995−2008

Variable	*Mean*	*Std. Dev.*	*P25*	*Median*	*P75*
Earnings (NOK)	311,800	171,300	226,400	290,000	364,800
Capital income (NOK)	6,300	22,100	100	700	3,300
Transfers (NOK)	9,300	18,600	0	0	12,000
Income taxes (NOK)	88,500	75,100	52,100	73,900	104,800
Marginal tax rate	40%	8.6%	35.8%	35.8%	49.3%
Observations		21,086,627			
Individuals		2,607,593			

Notes: Nominal income levels are inflated or deflated to an average level over the period 1995−2008 using observed annual growth in median income. 1 NOK corresponds to about EUR 0.125 or USD 0.2.

4.3 Description of data

Administrative data for the complete Norwegian population is used to create an unbalanced panel of wage earners for the period 1995−2008, see e.g. Statistics Norway (2005). The data include detailed information from income tax returns, linked to other administrative registers to provide information on individual characteristics, such as gender, age, education level, field of education, marital status and country of origin. Family and household information makes it possible to further control for civil status and number of children.

The analysis is restricted to the universe of wage earners aged 25−62, defined as having wage earnings as their only source of labor income. Thus, individuals with any income from self-employment, students and individuals receiving pensions or unemployment benefits are excluded from the sample. I also exclude individuals with very high (the highest percentile) or negative capital income.

Marginal tax rates are computed by a tax simulator.[14] When constructing synthetic net-of-tax rate changes, earnings in period $t-1$ is inflated to period $t+1$ and t, respectively, by using median growth in earnings.

Table 1 reports summary statistics for the pooled wage earner sample where nominal income levels are inflated or deflated to an average level over the period 1995−2008 using observed annual growth in median income. Figure A.2 in the Appendix provides a graphical presentation of income and tax developments over the period from 1995 to 2008.

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[14] The marginal tax rates are calculated on the basis of a five percent increase in earnings. This means in effect that the kink points in the tax schedule are smoothed. In fact, there is no visible bunching of wage earners at kink points.

4.4 Observed mean reverting pattern

Both mean reversion and trends in the income distribution are well-known empirical challenges to obtain unbiased estimates of the ETI, as the net-of-tax rate instrument is constructed using lagged income. Mean reversion refers to individuals with high/low income in period t, due to a temporary shock (ν_{it}), who return to their normal income level in period $t+s$, thus inducing an observed negative correlation between initial income level and income growth. Trends in the income distribution refer to heterogeneous growth rates across income classes which can be revealed by repeated cross-sectional data.

Figure 2 presents descriptive evidence in support of a persistent mean reverting pattern for Norwegian wage earners. The figure depicts change in log income (income growth) against previous income level, using a fourth-order local polynomial regression plot. To isolate the mean reverting effect, it only includes observations with no expected tax rate changes, i.e., the synthetic tax rate change is zero. In panel A of Figure 2 there is a negative correlation between base year income (period t) and income growth (period $t, t+1$). This is expected as $\log(z_{it})$ is positively correlated with ν_{it}, see Eq. (1), and consequently negatively correlated with $\triangle\nu_{it+1} = \nu_{it+1} - \nu_{it}$. Mean reversion seems to be particularly pronounced for the lower parts of the income distribution and for the top incomes. However, also in panel B there is a similar pattern between lagged income (period $t-1$) and income growth (period $t, t+1$), although to a lesser extent (notice the scaling of the vertical axis). To show that the pattern in panel B is not explained by a lower order moving average process of the transitory element of the error term, the income level is lagged to periods $t-2$ and $t-3$ in panels C and D, respectively: The persistent mean-reverting pattern suggest an autoregressive component in earnings.[15]

Figure A.3 in the Appendix shows that the cross-sectional earnings distribution is fairly stable over time, suggesting that the mean reverting pattern cannot be explained by trends in the income distribution.[16] Moreover, controlling for individual characteristics does not absorb the mean reverting pattern along the income distribution.

Given the mean reverting pattern in panel B, C and D, the tax rate instrument constructed on the basis of lagged base year income (following Weber, 2014) is not exogenous to the error terms of the conventional specification, see Eq. (1). Thus, similar to previous approaches by Auten and Carroll (1999), Gruber and Saez (2002) and Kopczuk (2005), the synthetic tax

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[15] If ν_{it} follows an MA(k) process, then the error term, $\Delta\nu_{it}$, is uncorrelated to $\log(z_{it-1-k})$. Moffitt and Gottschalk (2002) find that the earnings structure of income is best approximated by an ARMA(1,1) process.

[16] The cross-sectional earnings trends include a small compression in the lower half and a modest widening in the upper part of the income distribution. In the absence of these income trends, the mean reverting pattern in Figure 2 would likely be slightly less (more) pronounced at the lowest (highest) part of the income distribution.

rate instrument is only valid conditional on the lagged income level (using the same lags as those used to instrument the net-of-tax rate change). To obtain unbiased ETI estimates of the conventional static approach in Section 5, I thus include a function of log income, lagged $(t-1)$ in the regression analysis.[17]

The observed persistent mean reverting pattern is, on the other hand, consistent with the dynamic specification of a gradual earnings adjustment, as described in Section 3. Remember that all shocks have a gradual impact on earnings according to Eq. (2).[18] The dynamic formulation picks up the autoregressive component of earnings in the parameter ρ. Thus, the more persistent the mean reverting pattern, the slower is the earnings adjustment process, which implies a larger discrepancy between first-year and longer-term ETI. Note that although the conventional static specification control for lagged base year income in the regression analysis, it ignores the feedback effect which arises from sluggish earnings adjustment.

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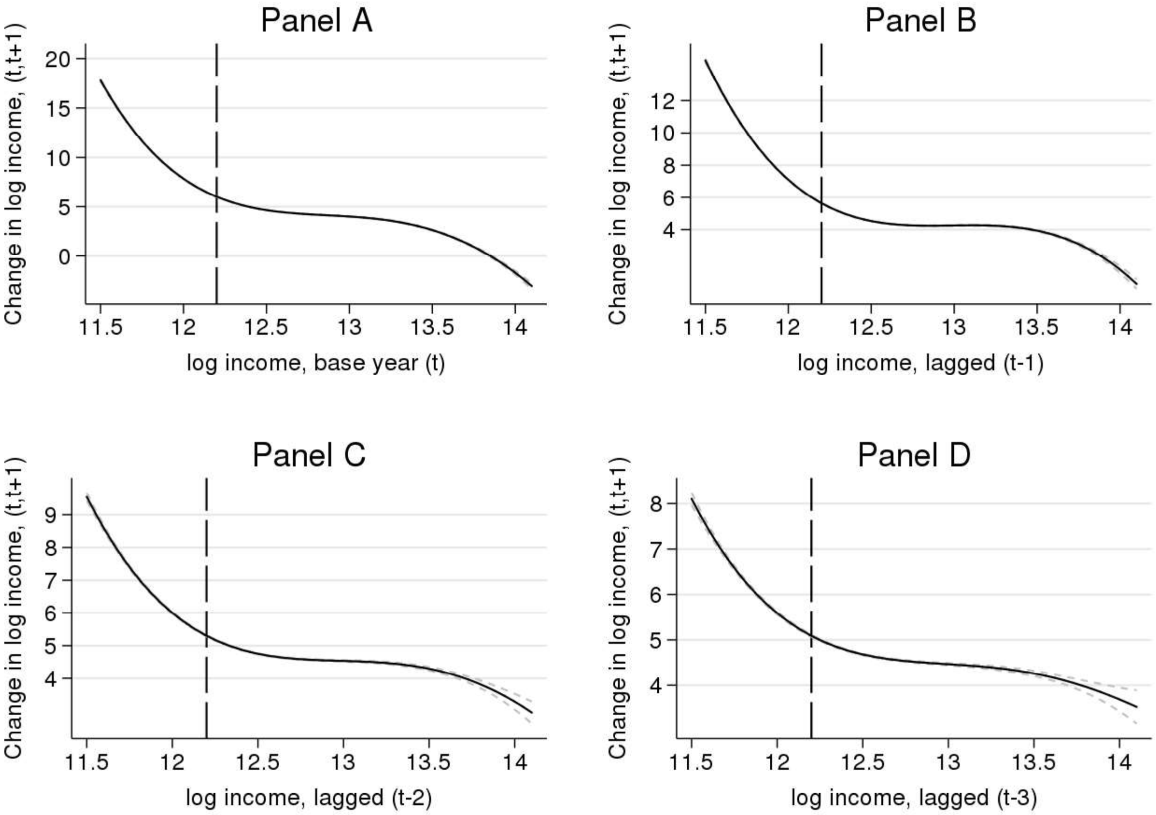
[17] Weber (2014) also include the lagged base year income level in the regression analysis, but then as a proxy for permanent income, to control for heterogeneous trends in the income distribution.

[18] Gradual earnings adjustment does not explain why the mean reverting pattern is especially pronounced in the lower and upper parts of the income distribution. To avoid making assumptions regarding a more complicated earnings process at the tails of the distribution, a lower income cut-off is introduced in the regressions (indicated by the dashed lines in Figure 2). As a robustness check, a higher income cut-off is also imposed.

Figure 2. Income growth rates against previous income levels, 1995−2008



Notes: Mean change in log income against lagged income levels. Only observations with no expected tax rate changes (the synthetic tax rate change is zero) are included. Income is adjusted to an average year. The panels are obtained by a fourth-order local polynomial regression plot. The thin dashed lines are 95% confidence intervals. The lower income restriction in the regression analyses imposed at income percentile 20 is indicated by the dashed vertical line.

5 ETI estimation results

5.1 Graphical evidence

Before turning to the results of the empirical regression models, preliminary descriptions of how the synthetic net-of-tax rate change, $\Delta\log(1\text{-}\tau_t)^{synth} = \log(1-\tau_{t+1}(z_{t-1})) - \log(1-\tau_t(z_{t-1}))$, varies with the dependent variable, $\Delta\log(z_t) = \log(z_{t+1}) - \log(z_t)$, are provided. As the synthetic tax rate change is only exogeneous conditional on z_{t-1} (as shown in the previous section), individuals are categorized into nine groups according to their income percentile in the year $t-1$. Figure 3 depicts $\Delta\log(1\text{-}\tau_t)^{synth}$ and $\Delta\log(z_t)$ for the time period 1996−2008, after year-specific and group-specific averages have been deducted.[19] The vertical axis measures the synthetic net-of-tax rate change (in percent) on the left-hand side, and the change in log income (in percent) on the right-hand side.

There seems to be a positive relationship between the synthetic net-of-tax rate change and the dependent variable as expected if ETI is positive. As shown by the scaling of the vertical axes, the percentage changes in the net-of-tax rates are from four to ten times as large as the change in income, which indicates that the ETI is relatively small (at most 0.2). As I shall return to, this is supported by the regression results in Sections 5.2 and 5.3.

According to a gradual earnings adjustment, as described in Section 3, the net-of-tax rate change is expected to have the largest effect (in terms of income growth) initially, and thereafter gradually diminishing effects. But as the tax schedule change frequently, it is difficult to single out the effect of each reform graphically.[20]

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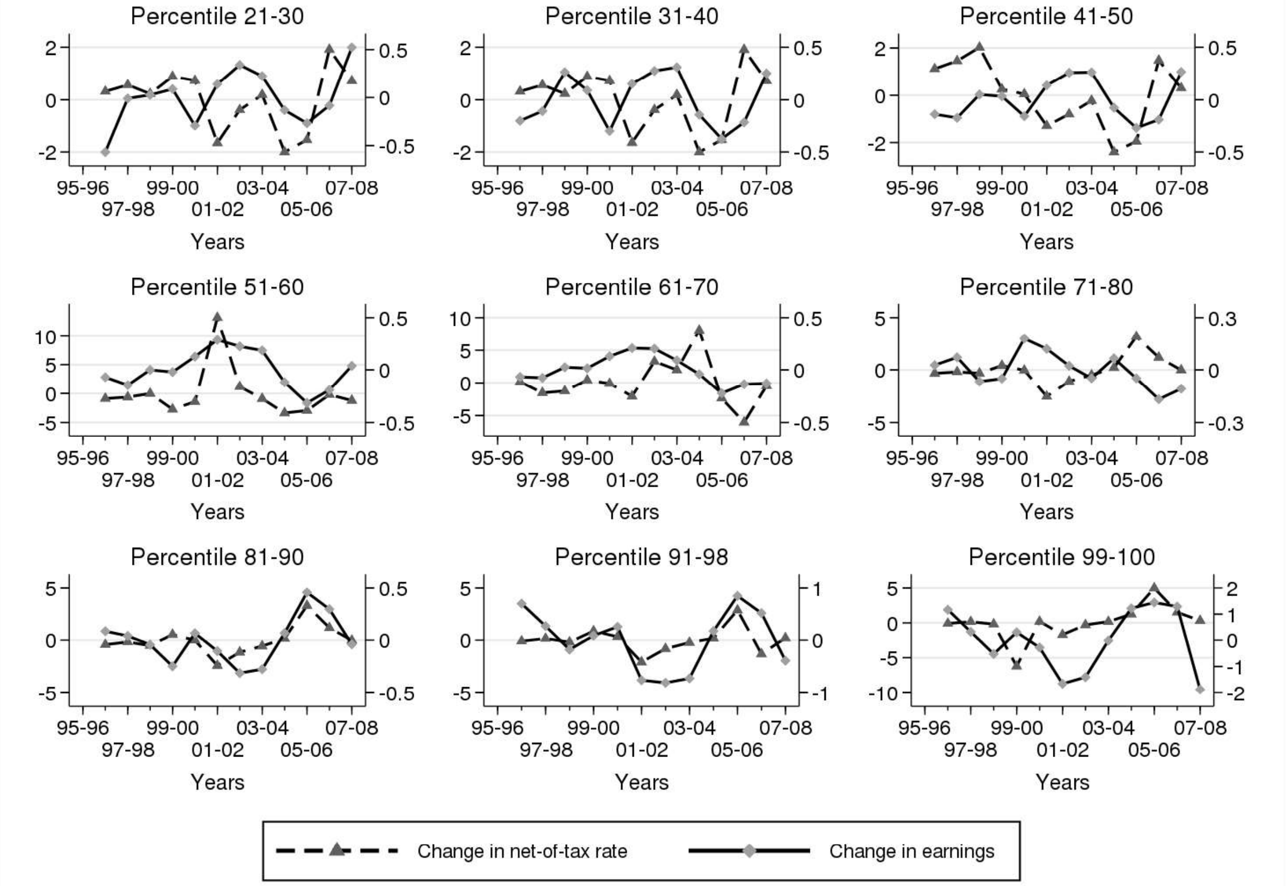
[19] Group specific effects remove heterogeneity in growth rates between the nine categories of individuals.

[20] Figure A.4 in the Appendix provides additional information on how observed income vary by the synthetic net-of-tax rate change, when following the same group of individuals over time, distinguishing between three reform periods. The figure illustrates that the parallel trend assumption does not hold, and again highlights the importance of controlling for previous income level (as shown in Section 4.4). Furthermore, Figure A.5 provides an alternative graphical illustration of reform periods (treatment) and pre-reform periods (control) by lagged income level (corresponding to Fig. 3 in Weber, 2014). The synthetic net-of-tax rate changes of the respective reform is depicted to visualize the degree of treatment along the income distribution. The results are not conclusive regarding the earnings effects of the net-of-tax rate changes, which again suggests that the behavioral responses are rather small and sluggish.

Figure 3. Graphical descriptions of income responses to net-of-tax rate changes



Notes: The vertical axis measures the change in log net-of-tax rate (in percent) on the left-hand side, and the change in log income (in percent) on the right-hand side for the time period under consideration (1996−2008). Individuals are categorized according to their income percentile in the year *t*-1. Category-specific and year-specific averages are deducted.

5.2 ETI estimates of the conventional static approach

In the present section, ETI estimates derived by the conventional approach are presented. The estimates are obtained from Eq. (1) where Δ refers to $(t, t+s)$ and the net-of-tax rate change is instrumented by the synthetic change, using the individual's lagged income level (period $t-1$), as suggested by Weber (2014). All s-year (overlapping) differences over the period 1996-2008 are stacked in one 2SLS regression.

The main results are given in Table 2, where the time span s is set equal to three years, following the standard procedure in the literature.[21] The first column of Table 2 presents the negative raw estimate of a specification without any control variables (only including year-fixed effects). The estimate is biased by the persistent mean reverting pattern as demonstrated in Section 4.4 (see Figure 2, panel B), where middle- and high-income earners mostly affected by the tax rate changes are associated with a lower income growth (in absence of the tax rate change). To avoid mean reversion or heterogeneous growth rates at the bottom of the income distribution a lower income cut-off applies (at income percentile 20) in the second column, and the ETI estimate becomes small and positive.[22] In the third column, the ETI estimate is slightly larger, when heterogeneous growth rates are controlled for by including a third order polynomial of log income in period $t-1$.[23] The preferred baseline regression is presented in the fourth column, where also a full set of individual characteristics (defined in period $t-1$) is included, given by gender, age, marital status, number of children under and over the age of 6, residence in densely populated areas, non-Western origin, years of education, dummies for field of education and wealth. Full regression output is provided in Table A.3 in the Appendix. It is noted that the first-stage F-statistics for the instrument is very large. Moreover, the synthetic tax rate instrument is strongly significant in the first-stage regression, as shown in Table A.4 in the Appendix.

The ETI estimate of the preferred baseline regression is 0.11 and statistically significant.[24] Compared to the results of other ETI studies this estimate is rather small,[25] which can

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[21] When $s = 3$, there are (at most) ten observations of each individual: year 1999 is related to 1996, 2000 is related to 1997, ..., 2008 is related to 2005.

[22] Using an income cut-off is common practice in the literature; see e.g. Gruber and Saez (2002) and Weber (2014). The income restriction applies for income in periods $t-1$ and period t. In the robustness check results reported in Table A.5 in the Appendix, it is shown that the results are robust to alternative income restrictions. Remember that the tax schedule changes considered only affect individuals in the upper half of the income distribution.

[23] It is standard in the literature to use either polynomials or a 10-piece spline of log income to make the control more flexible. See robustness tests in Table A.5 in the Appendix for a specification with splines.

[24] The results of several robustness tests of the present analysis are provided in Table A.5 in the Appendix. The tests include alternative income controls, income weights, alternative cut-off points, division into two shorter periods and alternative data restrictions.

[25] According to Saez et al. (2012) estimates of elasticity of taxable income from the US (after Feldstein, 1995) are found to range from 0.12 to 0.4. The most recent contributions report even higher elasticities:

be explained by wage earners having limited opportunities for avoidance and evasion due to the widespread use of third-party reporting by employers (Kleven and Schultz, 2014). Furthermore, the estimated earnings responses do not include any possibilities for itemized deductions, which means that estimates are closest in spirit to broad income elasticities, rather than elasticities of taxable income.[26] Finally, smaller elasticities can be expected for rather modest and rapid tax changes (as those analyzed here) in the presence of optimization frictions as discussed by Chetty (2012). The results are in line with both Thoresen and Vattø (2015) and Kleven and Schultz (2014), who find small estimates, of about 0.05, for wage earners of Norway and Denmark, respectively.[27]

Remember that the main point of the present paper is to demonstrate that the conventional method of estimating ETI is not well designed to capture the effect of sluggish earnings responses. This is not only because the conventional estimate is a combination of short-term and longer-term effects but also the methodological problems that arises from increasing the time span further.

Figure 4 illustrates the methodological problem of using the conventional approach to obtain longer-term responses. The figure presents ETI estimates when the time window, s, of the preferred baseline regression, is varied. The medium-term responses (three- or four-year spans) are larger than short-term responses (one-year span), which can be explained by gradual earnings adjustment (in line with the dynamic specification results in the next subsection). However, when s is increased further ($s = 5, 6, 7$) the estimates decrease. The likely reason is that it becomes increasingly challenging to distinguish tax responses from heterogeneous growth rates, as the number of overlapping s-year differences are reduced when s increases. Ultimately, a procedure involving very long time intervals is equivalent to the case of analyzing two years of data where adding lagged income controls destroy identification by absorbing much of the independent variation in tax rates, as argued by Saez et al. (2012). Moreover, although multiple tax changes, as well as episodes of both increases and decreases in tax rates, are favorable for identification, tax variation that have been reversed within each time span is lost when using wide time windows. I thus conclude that the conventional

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Weber (2014) reports elasticities of 0.5-0.9 for taxable income in the US. Doerrenberg et al. (2017) report elasticities of 0.5-0.7 for taxable income using German data.

[26] Broad income elasticities tend to be smaller than elasticities of taxable income, see the meta-study by Neisser (2017). Gruber and Saez (2002) and Weber (2014) report estimates for broad income of 0.12 and 0.4, respectively, using US data. Doerrenberg et al. (2017) find elasticities of 0.3 for broad income using German data, but suggest that the permanent effect is much smaller (0.07).

[27] Also, Aarbu and Thoresen (2001) find small responses (0-0.2) of the Norwegian tax reform of 1992. Note that the estimated elasticities reflect average treatment effects of the treated individuals and may therefore differ dependent on the reform utilized to obtain identification. For instance, whereas we analyze a reform that affected mostly above median-income earners, Lehmann et al. (2013) estimate an elasticity of 0.2 for gross labor income attributable to a French tax reform that affected low or median-income individuals.

Table 2. Estimates of the ETI. Results of the conventional static panel data approach

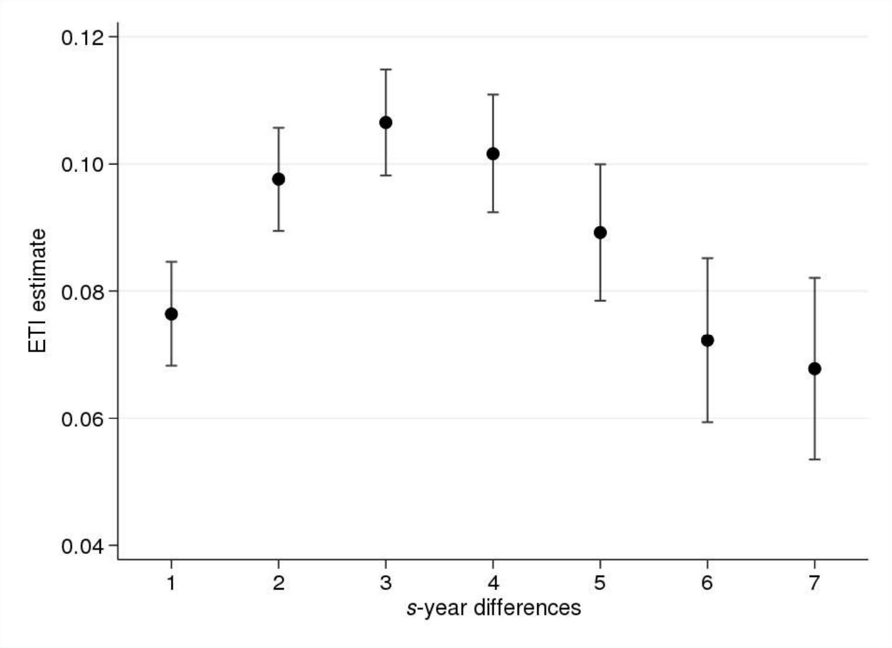
	(1)	(2)	(3)	(4)
ETI (e)	-0.1083***	0.0898***	0.1066***	0.1065***
	(0.0058)	(0.0037)	(0.0043)	(0.0043)
Income restrictions	None	>20th %ile	>20th %ile	>20th %ile
Income controls	No	No	Yes	Yes
Individual characteristics	No	No	No	Yes
Observations	10,625,240	8,554,092	8,554,092	8,493,569
Individuals	1,814,594	1,511,855	1,511,855	1,493,541

Notes: Each column is estimated by 2SLS, stacking all three-year differences $(t, t+3)$ over the period 1996−2008. All regressions include year-fixed effects. Income restrictions applies to income in period t and $t-1$. Income controls include a third order polynomial of lagged income (period $t-1$). Individual characteristics are measured in period $t-1$ and include gender, age, marital status, number of children under and over the age of 6, residence in densely populated areas, non-Western origin, years of education, field of education and wealth. Standard errors (reported in parentheses) are heteroskedasticity-robust and clustered at the individual level. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

approach fails to provide convincing long-term estimates of ETI.

As the dynamic specification (presented in the next subsection) puts more structure on the adjustment pattern (for example, whether the reform happened one or three years ago is of significance), it becomes easier to distinguish tax responses from other systematic fluctuations in reported income such as heterogeneous income growth. And because the long-term ETI is derived from the dynamic model coefficients, identification of long-term effects does not rely on using wide time windows with little tax variation.

Figure 4. ETI estimates obtained by varying the time span of the conventional approach



Notes: The figure illustrates how the conventional approach fails to obtain longer-term responses when increasing the time differences. Estimates are obtained by varying the time window, s, of the conventional baseline regression. Each estimate is obtained by 2SLS, stacking all s-year differences $(t, t+s)$ in the period 1996−2008. The spikes represent the 95 percent confidence intervals of each estimate. All regressions include year fixed effects, income controls and individual characteristics. A lower income cut-off applies (at income percentile 20) to income in period t and $t-1$. Income controls include a third order polynomial of lagged income (period $t-1$). Individual characteristics are measured in time period $t-1$ and include gender, age, marital status, number of children under and over the age of 6, residence in densely populated areas, non-Western origin, years of education, field of education and wealth. Standard errors are heteroskedasticity-robust and clustered at the individual level.

5.3 Results of the dynamic approach

In the following we turn to ETI estimates derived from the alternative model where earnings are allowed to develop dynamically. Recall that when allowing for gradual earnings adjustment, the long-term ETI estimate can be derived from $e = (\frac{\tilde{e}}{1-\rho})$, where $\tilde{e}$ is the short-term response and ρ reflects the estimated fraction of annual earnings adjustment.

Now, all one-year differences $(t, t+1)$, given by Eq. (3), in the period 1996−2008 are stacked in one 2SLS regression. The synthetic change in the net-of-tax rate is again used as an instrument for the tax rate change, and the previous income level (period $t-1$) serves as an instrument for the lagged dependent variable, following Holmlund and Söderström (2011). This implies that the lagged income level enters in both the conventional static and the dynamic specification, either as a control for heterogeneous growth rates along the income distribution (conventional approach), or as an instrument of lagged income growth (dynamic approach).

The estimation results of the dynamic specification are presented in Table 3. The first column presents the estimates of the simplest regression without lagged income growth and without control variables. This is analogous to the first column of Table 2, but now using one-year differences. In the second column the specification is made dynamic, as lagged income growth enters. In the third column individual characteristics are included,[28] and in the fourth column a lower income cut-off applies (at income percentile 20).[29] The fourth column in Table 3 presents results for the preferred baseline specification of the dynamic model.[30] All the first-stage F-statistics are very large, so weak instruments should be of no concern. Moreover, the instruments are strongly significant in the first-stage regression, as shown in Table A.4 in the Appendix.

According to the preferred specification, the estimated short-term elasticity ($\tilde{e}$), is approximately 0.09 and the fractional adjustment, symbolized by ρ, is about 0.36. The latter means that about two thirds ($\lambda = 1 - \rho$) of the gap between desired (latent) earnings and the previous period's earnings is reduced each year; see Eq. (2). The estimates of $\tilde{e}$ and ρ imply that the long-term ETI estimate of $e = (\frac{\tilde{e}}{1-\rho})$ is approximately 0.15. Both estimates are clearly significant. In Section 6, I will return to a graphical presentation of results over time.

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[28] As in the static specification, individual characteristics are measured in period $t-1$ and given by gender, age, marital status, number of children under and over the age of 6, residence in densely populated areas, non-Western origin, years of education, dummies for field of education and wealth.

[29] The income restriction applies to income in periods $t-1$ and period t. In the robustness checks reported in Table A.6 in the Appendix it is shown that the results are robust to alternative income restrictions.

[30] Although the results for specifications (2)-(4) of Table 3 are similar, the preferred specification (4) provides more robust results for small changes in samples or instruments than specifications (2) and (3). Moreover, it is preferable to compare similar specifications of the static and dynamic model; see full regression output in Table A.3 in the Appendix.

Table 3. Results of the dynamic panel data approach

	(1)	(2)	(3)	(4)
Short-term, elasticity ($\tilde{e}$)	0.0510***	0.0931***	0.0902***	0.0930***
	(0.0090)	(0.0101)	(0.0100)	(0.0044)
Lagged income growth (ρ)		0.3482***	0.3748***	0.3613***
		(0.0017)	(0.0017)	(0.0027)
ETI, $e = (\frac{\tilde{e}}{1-\rho})$	0.0510***	0.1428***	0.1443***	0.1456***
	(0.0297)	(0.0297)	(0.0273)	(0.0130)
Individual characteristics	No	No	Yes	Yes
Income restrictions	None	None	None	>20th %ile
Observations	14,395,216	14,395,216	14,106,613	11,326,117
Individuals	2,137,952	2,137,952	2,069,099	1,730,943

Notes: Each column is estimated using 2SLS, stacking all one-year differences $(t, t+1)$ in the period 1996−2008. All regressions include year fixed effects. Individual characteristics are measured in time period $t-1$ and include gender, age, marital status, number of children under and over the age of 6, residence in densely populated areas, non-Western origin, years of education, field of education and wealth. Income restrictions applies to income in periods t and $t-1$. Standard errors (reported in parentheses) are heteroskedasticity-robust and clustered at the individual level. The standard errors of e are obtained by the Delta method. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

There are only a few comparable studies on long-term ETI derived from a dynamic model. Holmlund and Söderström (2011) find estimates of about 0.1−0.3 for males when the Swedish tax reform of 1995 is used as identification, whereas Bækgaard (2014) reports long-term elasticity estimates of 0.1-0.4 by specifying an error-correction model for Denmark.[31] Holmlund and Söderström (2011) compared the results of their dynamic specification to the specification by Auten and Carroll (1999), for which they obtained an elasticity of 0. However, because their tax rate instruments are constructed differently in the two approaches, the differences in results cannot be attributed to the gradual earnings adjustment.[32]

The results of several robustness tests of the present analysis are provided in Table A.6 in the Appendix. The table includes results for an alternative GMM-difference specification (Arellano and Bond, 1991), other base year income controls, weights and cut-off points, as well as alternative data restrictions.

The results of robustness checks with virtual income effects included in both the con-

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[31] Holmlund and Söderström (2011) allow for both a lagged dependent variable and a lagged tax rate change in their specification, but the latter does not affect the ETI estimate of the present analysis, see robustness test in Table A.6 in the Appendix.

[32] Similar to my findings, Bækgaard (2010) and Bækgaard (2014) suggest that long-term elasticities are higher, and short-term elasticities are lower than estimates obtained from the conventional approach. However, these conclusions were drawn based on experimental data only.

ventional static and the dynamic model specifications are presented in Table A.7 in the Appendix. Estimated income effects are small, which support the assumption that elasticity estimates can be viewed as approximations to compensated effects, as argued by Gruber and Saez (2002).

6 Comparing the results of the static and dynamic approaches

In the previous section I reported an elasticity estimate of 0.11 according to the conventional static specification, and a long-term estimate of 0.15 according to the dynamic specification. As shown in Section 3, the conventional static model estimate can be interpreted as an average of the first-, second- and third-year effects of the dynamic model, given by $\frac{\tilde{e}+\tilde{e}(1+\rho)+\tilde{e}(1+\rho+\rho^2)}{3} = \frac{0.09+0.13+0.14}{3} = 0.12$. Thus, the dynamic model almost perfectly replicates the results of the conventional static model. On the other hand, the conventional approach is not able to mirror the long-term effect of 0.15. In fact, we saw that the conventional approach failed in obtaining a convincingly estimates of ETI when the difference length was increased to more than three years.

For further illustration of the main results, Figure 5 shows how the estimated ETI's develop over time (after a permanent net-of-tax rate change) according to the dynamic model. The ETI estimate provided by the conventional static approach is for comparison depicted as a constant elasticity estimate over time. The dynamic model generates elasticities that gradually increase over time, as individuals gradually adjust their earnings to the optimal level. We can see that the earnings adjustment is completed after about five years, when the long-term estimate is approximately realized.[33]

Although the elasticities derived from the static and dynamic approach are statistically different in the long-term, they are both small. Nonetheless, it can be shown that the economic significance in terms of fiscal consequences may be relatively large. In the following I present the results of a simple simulation to illustrate this. Results are discussed in terms of the degree of self-financing of a tax change. The degree of self-financing is here measured as the percentage share of mechanical revenue loss from a tax rate cut that is offset by tax revenue generated by the behavioral effect in terms of increased earnings, similar to Thoresen et al. (2010). It follows that a share of 100 percent corresponds to the maximum point of the Laffer curve, where the mechanical tax loss is exactly offset by the increase in tax revenues generated by the increased tax base. For the sake of simplicity, I only consider tax revenues coming from income taxation, although increased wage earnings also affect other tax bases,

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[33] The adjustment period follows directly from the estimate ρ, as the difference between actual and desired earnings in each period is reduced by a fraction of $\lambda = 1-\rho$. After five years, $(1-\rho)(1+\rho+\rho^2+\rho^3+\rho^4) = 0.99$, 99 percent of the long-term ETI estimate is reached.

as payroll taxes and value added taxes.

Earnings responses are simulated on the basis of the estimated model coefficients for a hypothetical tax cut, where the top marginal tax rate is reduced from 50 percent to 45 percent, and where the surtax bracket begins at the level of median income. The estimated elasticities are assumed constant across income levels.

An example might serve to clarify: Consider an individual earning 1.5 times the median income ($1.5z_m$) before the tax reform. If the ETI is 0.1, then earnings are increased by 1 percent (because of the 10 percent increase in net-of-tax rate) such that the new chosen level of earnings is $1.515z_m$ after the tax reform. For this individual, the government has a mechanical loss of $0.5z_m \cdot 5\% = 0.025z_m$ due to the tax cut. But because of the individual's behavioral change, the government receives tax revenues for the additional $0.015z_m$, corresponding to $0.015z_m \cdot 45\% = 6.75 \cdot 10^{-3}z_m$. In other words, as $6.75 \cdot 10^{-3}z_m/0.025z_m = 0.27$, 27 percent of the mechanical revenue loss is offset by behavioral adjustment.[34]

On the assumption that the surtax bracket begins at the median income level and all individuals adjust their earnings according to the (average) ETI estimate, the simulation results for the population of wage earners are summarized in the graph to the right in Figure 5. The static model's elasticity estimate of 0.11 implies that about 29 percent of the mechanical revenue is offset by behavioral effects. In contrast, the estimates of the dynamic model imply that the degree of self-financing increases from 28 percent the first year to 43 percent after about five years. Thus, the offsetting effects are substantially different in the long-term, depending on the ETI estimates of the static and dynamic specifications.

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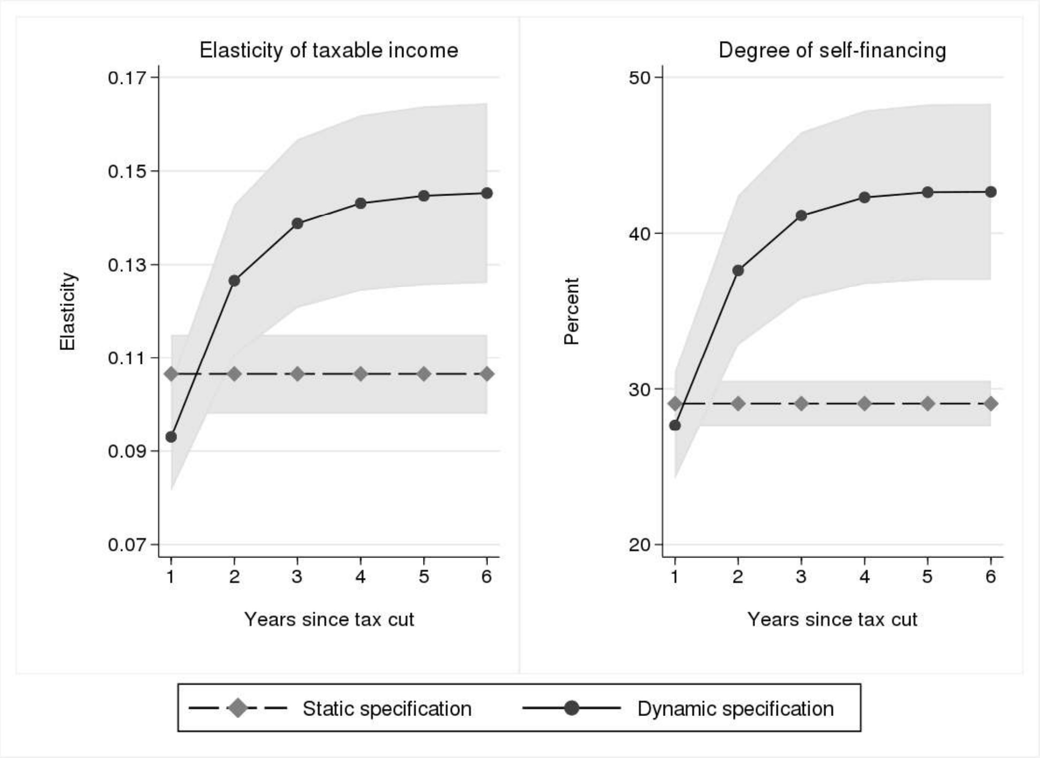
[34] Note that the degree of self-financing depends critically on the tax rate level of the new schedule (here set to 45 percent), for a given estimate of ETI.

Figure 5. Comparing the results of the static and dynamic specifications



Notes: Under the static model assumptions, the elasticity estimate (e) is constant across years since a (permanent) tax cut. The dynamic model estimates increase over time according to $\tilde{e}$, $\tilde{e}(1+\rho)$, $\tilde{e}(1+\rho+\rho^2)$, *etc.* After about five years the estimate is close to the long-term estimate of $\frac{e}{1-\rho}$. The degree of self-financing is measured as the percent of the mechanical tax revenue loss that is offset by revenue generated by behavioral effects in terms of wage earnings. Earnings responses are simulated on the basis of the estimated model coefficients for a hypothetical tax cut, where the top marginal tax rate is reduced from 50 percent to 45 percent, and where the surtax bracket begins at the level of median income. The shaded area represents the 95 percent confidence interval obtained by bootstrapped standard errors.

7 Conclusion

In estimating the elasticity of taxable income (ETI), analysts have settled on using three-year differences to allow all tax induced changes to materialize. The conventional approach of "stacking" overlapping differences (both over reform- and non-reform periods) is helpful to adequately control for past income level without absorbing the exogenous variation in the tax rates. However, stacking three years overlapping panels measures an average of the first, second and third year ETI, and thus underestimate long-term effects when the adjustment exceeds one year. In other words, the conventional approach is not well designed to capture the effect of real responses which are likely to be slow, such as adjustment in working hours, effort and occupational choice.

This paper is the first analysis to illustrate this effect by comparing the conventional specification (Weber, 2014) to a dynamic specification (Holmlund and Söderström, 2011). In particular it is shown how the dynamic formulation arises when allowing for gradual adjustment in earnings, and how the estimates of the two methods can be tested against each other.

When applied to Norwegian wage earners over a period with multiple changes in the tax schedule, I find that the ETI estimates of the dynamic specification increase from approximately 0.09 in the short-term (the first-year) to approximately 0.15 after about five years. Although the dynamic specification imposes some restrictions on the earnings process (as a fixed fraction of adjustment each period), and abstracts from possible anticipatory effects on the announcement of a tax reform, it reproduces the estimate of the conventional static model with overlapping three-year differences, given by 0.11. It is further demonstrated that the conventional approach fails to obtain longer-term estimates by extending the time span of each overlapping time difference. The problem is both that it captures an average of short- and longer term responses, but also the methodological obstacles that arises when the number of overlapping differences are reduced: there is little variation to distinguish heterogenous income trends from the instrumented net-of-tax rate changes.

To conclude, this study suggests that the conventional approach to estimating ETI is not well designed to capture sluggish earnings responses. Longer-term effects are difficult to estimate without adopting a dynamic framework.

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Appendix

Supplementary information about the estimation sample, including full regression output and robustness checks, are provided in the following.

Table A.1 provides more details on the two-step surtax rate schedule. The implied exogenous variation in the net-of-tax rates is described in Figure A.1. Figure A.2 provides an overview of the general income and tax development of the estimation sample. Figure A.3 shows that the cross-sectional income distribution is fairly stable over time.

In Table A.2 the estimation sample is divided into three groups based on the synthetic net-of-tax rate change, to demonstrate how "treatment" vary according to income and individual characteristics. Figure A.4 provides additional information on how observed income vary by treatment, when following the same group of individuals over time, distinguishing between three reform periods. The figure illustrates that the income trends cannot be expected to be parallel in absence of treatment, and thus again highlights the importance of controlling for previous income level (as shown in Section 4.4). Furthermore, Figure A.5 provides an alternative graphical illustration of reform periods (treatment) and pre-reform periods (control) by lagged income level (corresponding to Fig. 3 in Weber, 2014). The synthetic net-of-tax rate changes of the respective reform is depicted to visualize the degree of treatment along the income distribution. The results are not conclusive regarding the earnings effects of the net-of-tax rate changes, which again suggests that the behavioral responses are rather small and sluggish.

Full regression output of the static and dynamic baseline models is reported in Table A.3. The first-stage results of the baseline models are provided in Table A.4 and Figure A.6. Several tests of the robustness of the static and dynamic models are provided in Table A.5 and Table A.6, respectively. The tests include income weights,[35] alternative specifications[36] or controls for heterogeneous income trends,[37] alternative cut-off points, division into two

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[35] The baseline regressions are unweighted as in Weber (2014) and Holmlund and Söderström (2011). However, for welfare analyses, it has been argued that ETI weighted by income is the relevant parameter because it gives proportionally more weight to high-income taxpayers, as their response contributes proportionately more to the aggregate elasticity; see e.g. Saez et al. (2012).

[36] One of the alternative specifications of the dynamic model in Table A.6 is estimated by difference-GMM, as in Arellano and Bond (1991). Thus, all available income lags (in levels) are used as instruments (see Roodman, 2009) rather than only the income level in period $t-1$. The results are robust to this alternative method.

[37] For instance, Kopczuk (2005) argues that mean reversion and heterogeneous income trends across income groups are two separate phenomena, and proposes including two separate variables: 1) the log difference between base-year income and income in the preceding year, $\log(z_t) - \log(z_{t-1})$, to account for mean reversion and other transitory income effects, and 2) a function of income in the year preceding the base year, $\log(z_{t-1})$, to control for heterogeneous shifts in the income distribution. This specification is denoted as "Add differences" in Table A.5. As the differences are endogenous to the dependent variable, see Weber (2014), this is not my preferred baseline estimate.

Table A.1. Variation in the two-step surtax rate schedule over time, 1995−2008

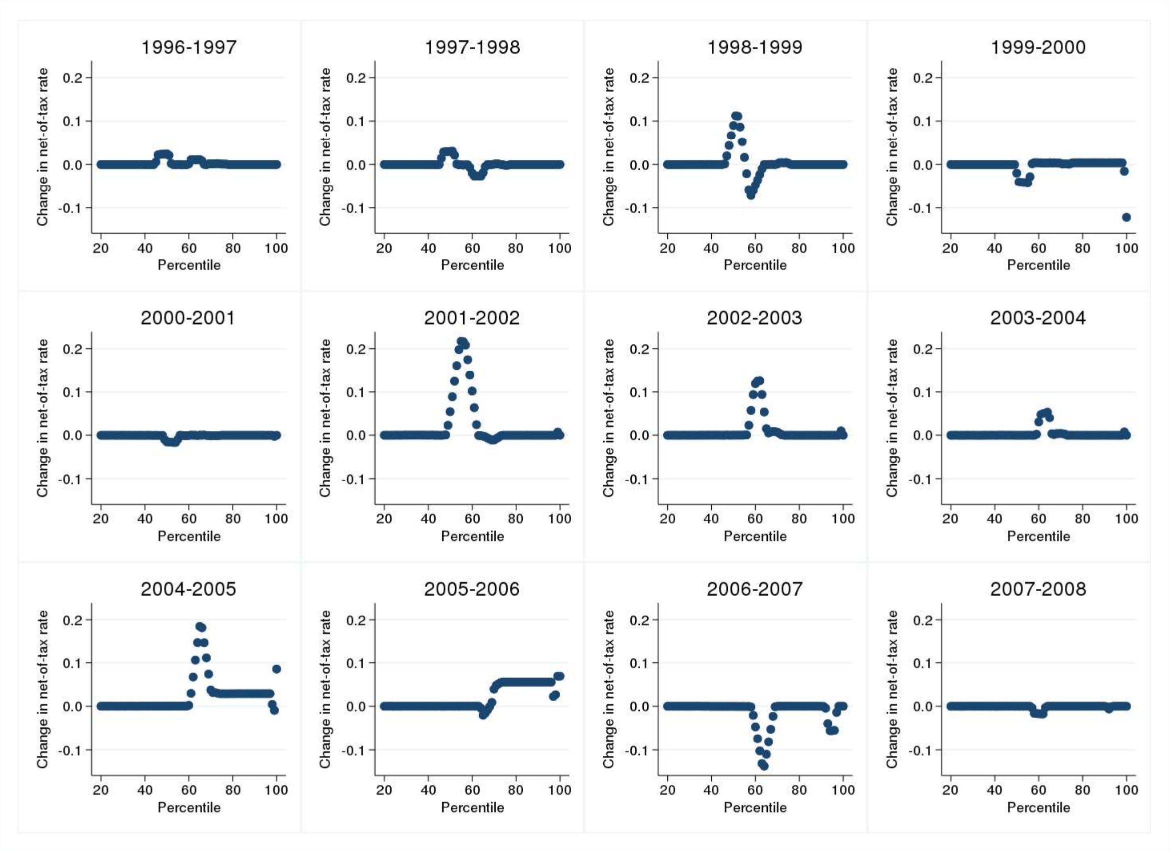
	First-step Started at Nominal income	 Percentile	 Tax rate	Second-step Startet at Nominal income	 Percentile	 Tax rate
1995	212,000	51th	9.5	239,000	66th	13.5
1996	220,500	51th	9.5	248,500	66th	13.5
1997	233,000	51th	9.5	262,500	66th	13.5
1998	248,000	52th	9.5	272,000	64th	13.5
1999	269,000	57th	13.5	-	-	-
2000	277,800	55th	13.5	762,700	99th	19.5
2001	289,000	54th	13.5	793,200	99th	19.5
2002	320,000	62th	13.5	830,000	99th	19.5
2003	340,700	64th	13.5	872,000	99th	19.5
2004	354,300	66th	13.5	906,900	99th	19.5
2005	381,000	70th	12.0	800,000	98th	15.5
2006	394,000	68th	9.0	750,000	97th	12.0
2007	400,000	63th	9.0	650,000	92th	12.0
2008	420,000	62th	9.0	682,500	92th	12.0

Notes: Percentile refers to the cross-sectional income percentile of the wage earner sample that corresponds to the nominal income level. In addition to the two-tier surtax rate schedule, earnings are taxed at a flat rate of 28 percent and at a social security tax rate of 7.8 percent.

shorter periods and alternative data restrictions. The results of both models are robust to small changes in specification or estimation sample, although excluding extreme growth filers and the top income percentile slightly reduces the ETI estimates.

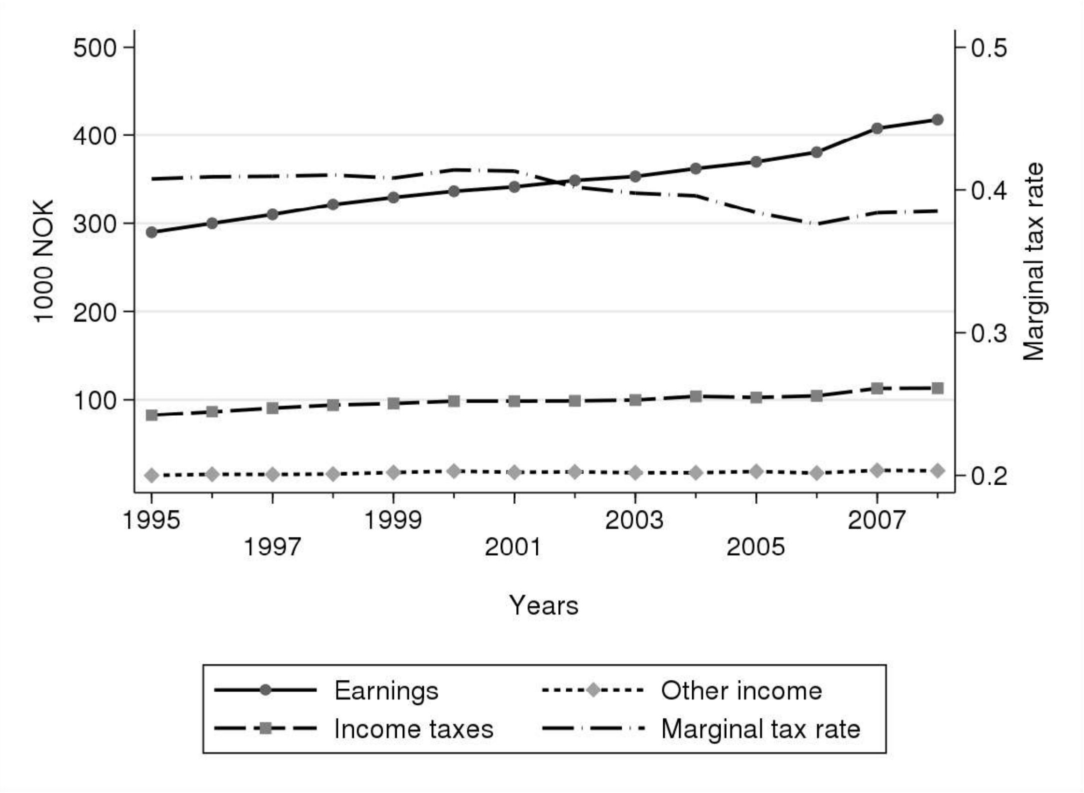
Table A.7 reports results taking explicit account of income effects in the regressions, using the approach suggested by Blomquist and Selin (2010) to establish virtual income. The estimated income effect is small and the effects on the implied compensated net-of-tax elasticities are similarly modest. This finding is consistent with previous ETI studies (Gruber and Saez, 2002; Lehmann et al., 2013; Kleven and Schultz, 2014; Thoresen and Vattø, 2015).

Figure A.1. Exogenous variation in the synthetic net-of-tax rate



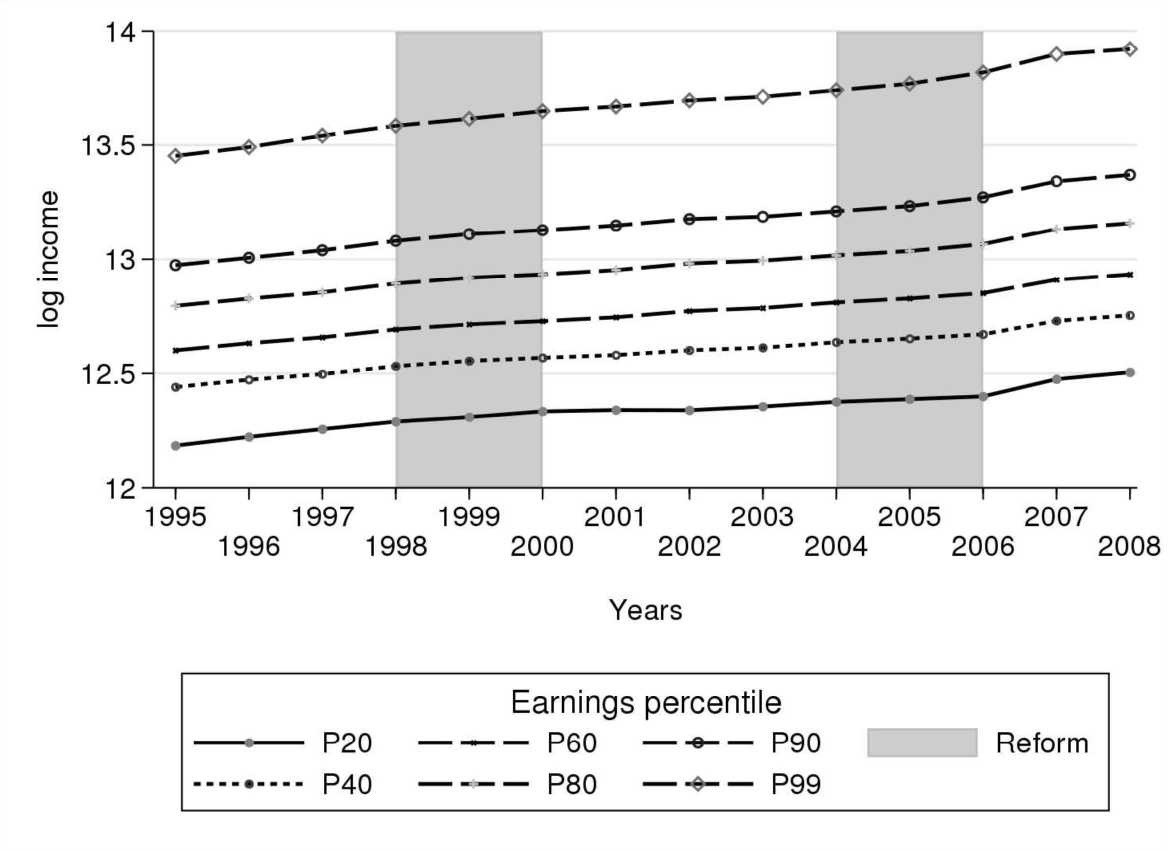
Notes: Percentile refers to the lagged income percentile of the wage earner sample in period $t-1$. Change in net-of-tax rate refers to the synthetic tax rate change given by $\Delta\log(1\text{-}\tau_t)^{synth} = \log(1-\tau_{t+1}(z_{t-1})) - \log(1-\tau_t(z_{t-1}))$, where z_{it-1} is inflated to period $t+1$ and t, respectively, using median growth in earnings. The marginal tax rates are calculated on the basis of a five percent increase in earnings.

Figure A.2. Average income and taxes by year, 1995−2008



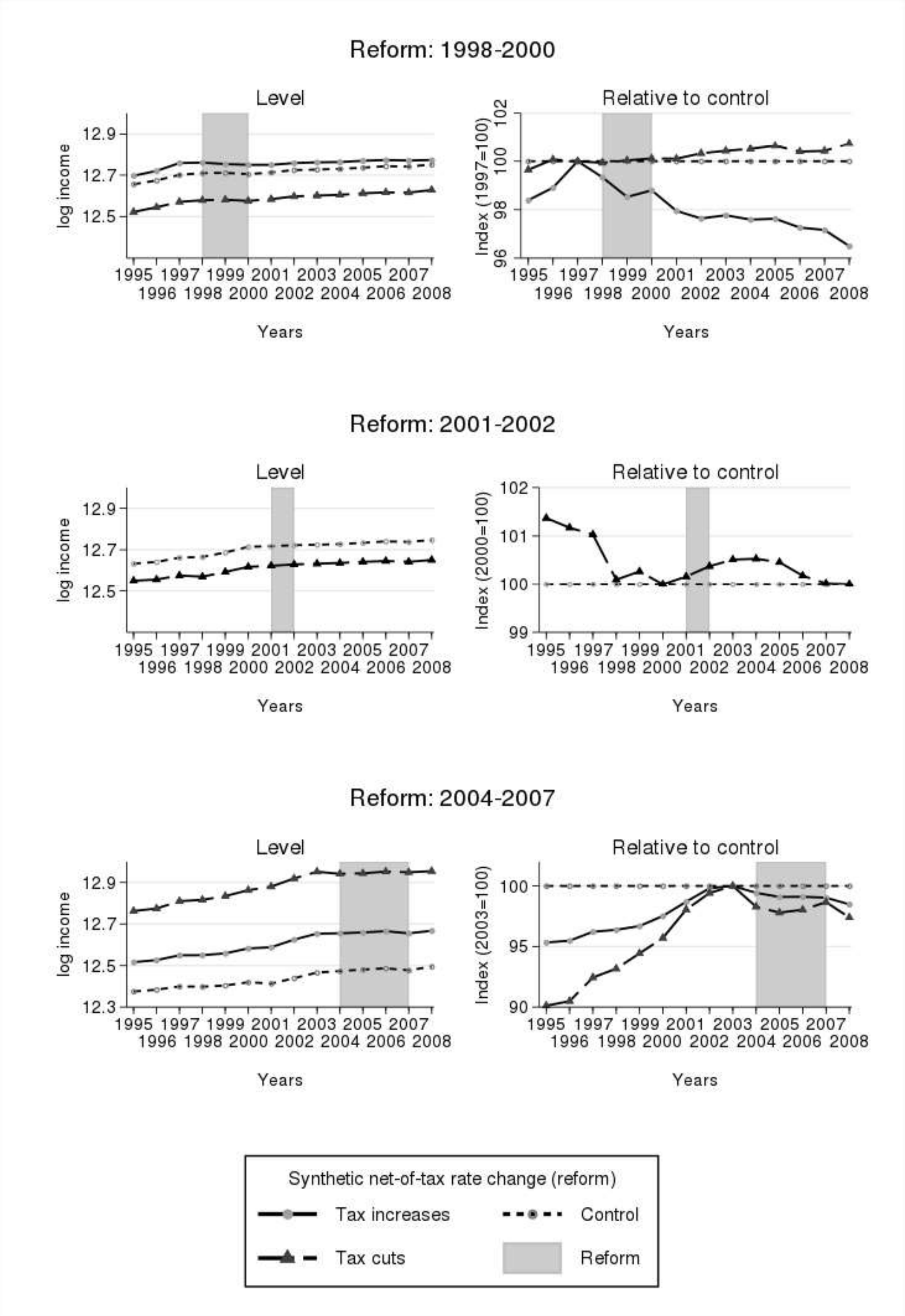
Notes: Average income and tax development over the period from 1995 to 2008 for the sample of wage earners. Other income consists of capital income and transfers.

Figure A.3. Cross-sectional income trends, 1995-2008



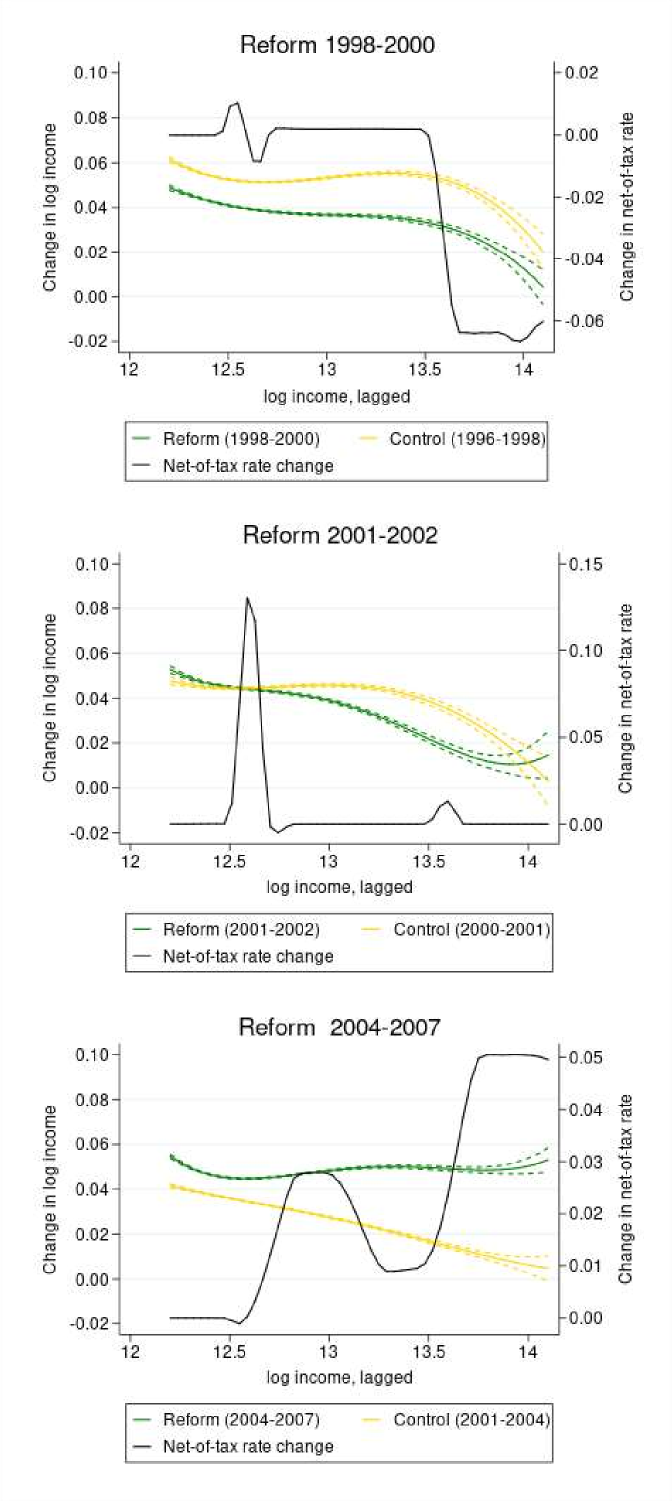
Notes: Average earnings for each percentile is obtained by repeating cross-sections of years 1995−2008.

Figure A.4. Income trends by the synthetic net-of-tax rate change



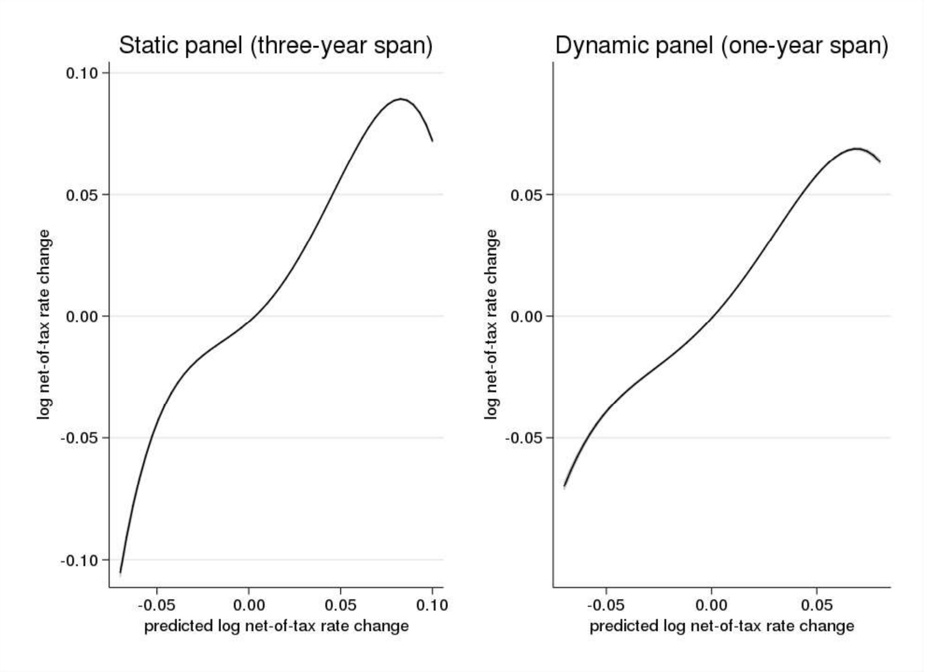
Notes: The figure depicts income trends by following the same group of individuals based on their synthetic net-of-tax rate change, $\Delta\log(1\text{-}\tau_t)^{synth}$ over three different tax reform periods. For instance, in the upper part of the figure, income in year 1999 is used to construct synthetic tax rate change over the period 1998-2000, and divide individuals into groups dependent on whether the synthetic tax rate instrument was negative (tax increases), positive (tax cuts) or zero (control group). In the middle part of the figure, individuals are categorized based on income in year 2000 (and the synthetic tax schedule changes 2001-2002) and in the lower part of the figure they are categorized based on income in year 2003 (and the synthetic tax schedule changes 2004-2007).

Figure A.5. Mean earnings change by lagged log earnings level



Notes: The figure depicts income growth, $\log(z_{t+s}) - \log(z_t)$, by lagged income, $\log(z_{t-1})$, for three different reform periods. The reforms affected the synthetic net-of-tax rate change, $\Delta\log(1\text{-}\tau_t)^{synth}$ over lagged income level as illustrated by the black line. For each reform period, the pattern is compared to a control period prior to the reform period.

Figure A.6. Graphical representation of first-stage estimates



Notes: A fourth-order local polynomial plot of the observed and predicted net-of-tax rate changes (the fitted values of the first-stage regressions). The left panel depicts three-year differences and the right panel depicts one-year differences. The thin dashed lines are 95% confidence intervals. The bandwidth is 0.16.

Table A.2. Individual characteristics by the synthetic net-of-tax rate change

	Tax increases		Control		Tax cuts	
	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.
Δlog(1-τ_t)^{synth}	-0.050	(0.044)	0.000	(0.001)	0.063	(0.052)
Δlog(z_{it})	0.049	(0.155)	0.043	(0.147)	0.040	(0.142)
Male	0.64	(0.48)	0.60	(0.49)	0.69	(0.46)
Age	41.6	(9.34)	41.6	(9.51)	42.1	(9.45)
Married	0.55	(0.50)	0.56	(0.50)	0.57	(0.49)
No. children under 6	0.32	(0.64)	0.31	(0.62)	0.31	(0.63)
No. children over 6	0.57	(0.87)	0.56	(0.86)	0.56	(0.88)
Non-Western origin	0.03	(0.16)	0.03	(0.17)	0.02	(0.15)
Residence in large city	0.13	(0.34)	0.13	(0.33)	0.14	(0.35)
Years of education	12.7	(2.52)	12.5	(2.55)	12.9	(2.57)
Wealth, 10^3 NOK	121	(462)	124	(518)	132	(475)
Income, 10^3 NOK	399	(163)	378	(161)	432	(179)
Marginal tax rate	0.423	(0.053)	0.423	(.066)	0.476	(0.037)
Observations	665,590		9,284,203		1,555,591	
Individuals	483,815		1,745,501		815,335	

Notes: The estimation sample over the period 1996, .., 2008 is divided into three groups based on the synthetic net-of-tax rate change, Δlog(1-τ_t)^{synth}, to demonstrate how tax treatment varies according to individual characteristics and the dependent variable, $\Delta log(z_t)$. A lower income-cut-off (>20th%ile) applies to all observations in periods $t-1$ and t. Income and individual characteristics are measured in period $t-1$. Wealth of zero or less is set to 1 in order to apply the natural log transformation in the regression analyses.

Table A.3. Full regression output of the baseline specifications

	Static panel (three-year differences)		Dynamic panel (one-year differences)	
Net-of-tax rate elasticity (e and $\widetilde{e}$)	0.1065***	(0.0043)	0.0930***	(0.0044)
Lagged income growth (ρ)			0.3613***	(0.0027)
Male	0.0318***	(0.0003)	0.0082***	(0.0001)
Age/10	0.0243***	(0.0012)	0.0179***	(0.0000)
Age squared/100	-0.0033***	(0.0001)	-0.0018***	(0.0001)
Married	0.0046***	(0.0002)	-0.0001	(0.0001)
No. children under 6	0.0113***	(0.0002)	0.0040***	(0.0001)
No. children over 6	0.0098***	(0.0001)	0.0032***	(0.0000)
Non-Western origin	-0.0278***	(0.0008)	-0.0115***	(0.0003)
Residence in large city	0.0035***	(0.0003)	-0.0023***	(0.0001)
Years of education	0.0092***	(0.0001)	0.0013***	(0.0000)
Log wealth /100	-0.0072***	(0.0016)	0.0000	(0.0000)
Log income	-0.0759***	(0.0009)	-	
Log income, squared	0.0347***	(0.0024)	-	
Log income, cubed	-0.0127***	(0.0017)	-	
Field of education (9 categories)	Yes		Yes	
Year fixed effects	Yes		Yes	
Constant	-0.0137***	(0.0031)	-0.0362***	(0.0012)
Observations	8,493,569		11,326,117	
Individuals	1,493,541		1,730,943	

Notes: The table presents the full regression output (second-stage of 2SLS) of the preferred static and dynamic specifications described in the fourth columns of Table 2 and Table 3, respectively. The dependent variable is income growth, $\Delta\log(z_{it})$, where Δ refers to s-year differences $(t, t+s)$ over the period $1996, .., 2008$. In the static model $s = 3$ and in the dynamic model $s = 1$. Income restrictions (>20th%ile) apply to income in periods t and $t-1$ for each time span. Individual characteristics are measured in period $t-1$. The static model includes a (centered) third order polynomial of lagged income (period $t-1$), and the dynamic model includes a lagged dependent variable instrumented by the lagged income level. First-stage results are reported in Table A.4. Standard errors (reported in parentheses) are heteroskedasticity-robust and clustered at the individual level. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table A.4. First-stage estimates

	Static panel	Dynamic panel	
	Δlog(1-τ_t)	Δlog(1-τ_t)	Δlog(z_{t-1})
Δlog(1-τ_t)^{synth}	0.3355***	0.3423***	-0.0244***
	(0.0007)	(0.0009)	(0.0010)
log(z_{t-1})		0.0164***	-0.0826***
		(0.0001)	(0.0002)
First-stage F-statistic	238,958	101,067	67,467
Observations	8,493,569	11,326,117	11,326,117
Individuals	1,493,541	1,730,943	1,730,943

Notes: The table presents first-stage 2SLS results of the preferred static and dynamic specifications. Δ refers to s-year differences $(t, t+s)$ over the period $1996, .., 2008$, where $s = 3$ in the static model and $s = 1$ in the dynamic model. The covariates in each column are the same as those included in the 2SLS estimates reported in Table A.3 (the coefficients are suppressed). Standard errors in parentheses, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table A.5. Robustness tests static panel

	Elasticity (e)	Std error	Observations
Ref.	0.1065***	(0.0043)	8,493,569
Alternative weights			
Weighted by income	0.1309***	(0.0081)	8,493,569
Heterogeneous income trends			
Linear	0.0820***	(0.0038)	8,493,569
10 Splines	0.1100***	(0.0037)	8,493,569
Add differences	0.1062***	(0.0043)	8,493,569
Alternative lower income cut-offs			
>Percentile 10	0.1052***	(0.0042)	9,562,744
>Percentile 30	0.1133***	(0.0043)	7,385,852
>Percentile 40	0.1171***	(0.0042)	6,259,643
Exclude top income filers			
1 % excluded	0.0907***	(0.0042)	8,326,170
5 % excluded	0.0831***	(0.0042)	7,697,559
Exclude extreme growth filers			
0.1% excluded	0.0993***	(0.0038)	8,480,265
1% excluded	0.0808***	(0.0031)	8,348,972
Sub-periods			
1996-2003	0.1136***	(0.0090)	4,059,924
2001-2008	0.0980***	(0.0048)	4,433,645

Notes: The reference (Ref.) corresponds to the preferred baseline regression of the static model, reported in the fourth column of Table 2 where all three-year differences $(t, t+3)$ are stacked over the period 1996−2008. All regressions include year fixed effects. Lower income cut-offs (>20th%ile in reference) applies to income in periods t and $t-1$. Income controls include a third order polynomial of lagged income (period $t-1$). Individual characteristics are measured in period $t-1$ and include gender, age, marital status, number of children under and over the age of 6, residence in densely populated areas, non-Western origin, years of education, field of education and wealth. Standard errors (reported in parentheses) are heteroskedasticity-robust and clustered at the individual level. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table A.6. Robustness tests dynamic panel

	Short-term, elasticity ($\tilde{e}$)	Std error	Elasticity ($e = (\frac{\tilde{e}}{1-\rho})$)	Std error	Obs.
Ref.	0.0930***	(0.0044)	0.1456***	(0.0130)	11,326,117
Alternative weights					
Weighted by income	0.0971***	(0.0062)	0.1456***	(0.0253)	11,326,117
Alternative specifications					
Add lagged tax rate	0.0948***	(0.0043)	0.1495***	(0.0127)	11,326,117
Polynomial of income	0.0925***	(0.0048)	0.1319***	(0.0189)	11,326,117
Difference-GMM	0.0980***	(0.0043)	0.1563***	(0.0125)	9,686,549
Alternative lower income cut-offs					
>Percentile 10	0.0973***	(0.0045)	0.1423***	(0.0152)	12,779,087
>Percentile 30	0.0921***	(0.0043)	0.1461***	(0.0125)	9,828,150
>Percentile 40	0.0826***	(0.0042)	0.1261***	(0.0128)	8,313,321
Exclude top income filers					
1 % excluded	0.0875***	(0.0064)	0.1358***	(0.0099)	11,126,295
5 % excluded	0.0756***	(0.0065)	0.1158***	(0.0099)	10,363,533
Exclude extreme growth filers					
0.1% excluded	0.0845***	(0.0038)	0.1322***	(0.0111)	11,309,127
1% excluded	0.0654***	(0.0030)	0.0944***	(0.0102)	11,136,453
Sub-periods					
1996-2003	0.0993***	(0.0063)	0.1587***	(0.0177)	6,283,218
2002-2008	0.0929***	(0.0059)	0.1463***	(0.0176)	5,998,510

Notes: The reference (Ref.) corresponds to the preferred baseline regression of the dynamic model, reported in the fourth column of Table 3, where all one-year differences $(t, t+1)$ are stacked over the period 1996−2008. All regressions include year fixed effects. Lower income cut-offs (>20th%ile in reference) applies to income in period t and $t-1$. Individual characteristics are measured in period $t-1$ and include gender, age, marital status, number of children under and over the age of 6, residence in densely populated areas, non-Western origin, years of education, field of education and wealth. Standard errors (reported in parentheses) are heteroskedasticity-robust and clustered at the individual level. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table A.7. Elasticity estimates of specifications with and without income effects

	Uncompensated net-of-tax elasticity	Non-labor income elasticity	Implied compensated net-of-tax elasticity
Static panel	0.1065^{***}	-	0.1065^{***}
	0.0875^{***}	-0.0068	0.0935^{***}
Dynamic panel, short-term	0.0930^{***}	-	0.0930^{***}
	0.1199^{***}	0.0167^{*}	0.1053^{***}
Dynamic panel, long-term	0.1456^{***}	-	0.1456^{***}
	0.1833^{***}	0.0255	0.1610^{***}

Notes: The implied compensated net-of-tax elasticity is estimated by the formula $\xi^C = \xi^U - \xi^R(1-\tau)z/V$ where ξ^C, ξ^U and ξ^R refer to the compensated, uncompensated and non-labor income elasticity, respectively; see Blomquist and Selin (2010). All estimates are obtained by 2SLS, stacking all s-year differences $(t, t+s)$ in the period 1996−2008, where $s = 3$ in the static panels and $s = 1$ in the dynamic panels. Income restrictions (>20th%ile) applies to income in period t and $t-1$. All regressions include year fixed effects and individual characteristics. Individual characteristics are measured in period $t-1$ and include gender, age, marital status, number of children under and over the age of 6, residence in densely populated areas, non-Western origin, years of education, field of education and wealth. The static panels include a third order polynomial of lagged income (period $t-1$), and the dynamic panels include a lagged dependent variable instrumented by the lagged income level. Standard errors (reported in parentheses) are heteroskedasticity-robust and clustered at the individual level. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.