THE SHORT-TERM RATIO OF SELF-FINANCING OF TAX CUTS: AN ESTIMATE FOR NORWAY’S 2006 TAX REFORM

Thor O. Thoresen, Jørgen Aasness, and Zhiyang Jia

This article discusses revenue estimating procedures for changes to the personal income tax. Using partial equilibrium revenue estimates of the personal income tax cuts introduced in Norway in 2006 as an example, we find wide variation in the estimates of the revenue costs of cuts depending on various factors, even in the short term. Our revenue estimates take into account labor supply responses and changes in revenues from payroll taxes and indirect taxes, and we compare our results to those obtained using current static revenue estimating procedures. In general, we find that more than 60 percent of the static revenue cost of personal income tax cuts is offset with higher tax revenues from other tax bases and higher personal income taxes due to increases in labor supply.

Keywords: tax revenue estimates, dynamic scoring procedures, microsimulation

JEL Codes: H24, H31

I. INTRODUCTION

Revenue estimation practices in the United States have recently received widespread attention (Diamond and Moomau, 2003; Altshuler et al., 2005; Auerbach, 2005; Carroll and Hrung, 2005; Page, 2005; Diamond, 2005; Gale and Orszag, 2005; Mankiw and Weinzierl, 2006; Feldstein, 2008; Leeper and Yang, 2008), but much less attention has been paid to this issue in other countries. In this paper, we consider this issue in the context of Norway, using as an example the personal income tax cuts enacted in 2006. Specifically, we estimate the effects of changing current Norwegian personal income tax revenue estimation procedures, which ignore behavioral responses and interactions between tax bases, with estimates reflecting behavioral effects and the revenue effects due to reform-induced changes in other tax bases.
Whereas the discussion in the U.S. case is primarily concerned with how to incorporate dynamic, macroeconomic effects into revenue estimates, given the 10-year budgeting period, we focus on estimating revenue for the next fiscal year. We shall therefore explore short-term revenue effects or partial equilibrium effects. As in the United States (Auerbach, 2005), we can classify current Norwegian revenue projection procedures as: (1) forecasts of revenues based on current policy, employing macro models and other types of information, and (2) predictions of revenue effects from suggested tax changes. In U.S. terminology, the first type is called *baseline*, the second *scoring*. We believe that it should be possible to improve the estimates produced by Norwegian scoring procedures because current procedures largely ignore the behavioral implications of changes to the personal income tax. They also fail to take account of the likely effects of such changes on revenues from other tax bases (for example, indirect and corporate taxes). In practical terms, this means that the budgets Parliament usually passes will be based on biased estimates of revenue effects. Current procedures came under particular scrutiny during the drafting of the 2006 personal income tax reform. The reform proposed significantly lower tax rates from relatively high levels, creating expectations of a substantial gap between cost measures with and without behavioral effects. Political parties in favor of deeper tax cuts were unhappy with the lack of information on supply side effects in the revenue estimates, which they believed exaggerated the revenue loss likely to result from the reform (Standing Committee on Finance and Economics Affairs, 2004).

This paper attempts to quantify the differences between current revenue estimating procedures in Norway and more ambitious methods. We use as our example the changes brought about by the 2006 tax reform. When personal income tax rates fall, as was the case in 2006, rising post-tax income (for given pre-tax income) induces increased consumption, and thus increased revenue from indirect tax bases — effects that are not currently reflected in personal income tax revenue estimates. The tax reductions also influence labor supply incentives. Labor supply responses, we contend, also affect revenue estimates in the short run, and we use a partial equilibrium labor supply model to estimate these effects. In addition to increasing personal income tax revenue, increases in labor supply also affect the payroll tax levied on employers. And, as pre-tax income rises, post-tax income and consumption rise too, increasing indirect tax revenues. We estimate the magnitudes of these various effects, i.e., behavioral effects and interactions with other tax bases, and compare aggregate measures from this more ambitious revenue estimating approach to estimates obtained under current static revenue estimating practices. The paper thus presents an estimate of the extent to which tax cuts may be “self-financing” due to such behavioral and interaction effects, as discussed by Lindsey (1987), Feldstein (1995, 2008), Carroll and Hrung (2005), and Mankiw and Weinzierl (2006).

Methodologically, our estimates are based on micro data, using simulation models that were designed to predict effects of tax changes. The personal income tax module, LOTTE-Skatt, a component of the Norwegian tax-benefit model system LOTTE (Aasness, Dagsvik and Thoresen, 2007), was designed precisely in order to calculate the
revenue and distributional effects of changes to the personal income tax. In conjunction with various other macroeconomic projection procedures, the module is used to define baseline revenue estimates in the Norwegian system. With respect to scoring, the LOTTE-Skatt module provides revenue estimates that ignore important behavioral responses to tax rate changes, such as labor supply adjustments, and reflect no interactions with other tax bases. To assess the effects on labor supply of changes in the personal income tax, a new module was therefore constructed, LOTTE-Arbeid, based on Dagsvik and Jia (2008). We use the new module to predict the labor supply effects of the 2006 reform which we translate into tax revenue effects, emphasizing model features that are consistent with the short-term perspective of the present study. Estimates of changes in indirect tax revenue are derived by combining information from two simulation models from Statistics Norway. First, household level information on expenditures on detailed commodity groups linked to estimates of reform-induced increases in post-tax income are derived from the microsimulation model LOTTE-Konsum. Second, effective marginal indirect tax rates for each commodity group are obtained from the CGE model MSG (Heide et al., 2004). Utilizing different assumptions regarding marginal consumption propensities, we predict for each household (in the LOTTE-Skatt and LOTTE-Konsum databases) consumption tax revenue contributions, which are then aggregated to national level estimates.

The plan of the paper is as follows. In the next section we discuss the effects to be included in a more sophisticated scoring procedure. Thereafter, we review the prominent features of the 2006 Norwegian tax reform, which are used to exemplify the effects of the alternative scoring methods. The tax reform resulted in a loss of revenue, caused in part by lower marginal tax rates at high income levels. However, the standard procedure disregards any increase in labor supply in response to lower taxes, so in the next section we estimate tax revenue generated by labor supply adjustments to the new schedule, including increased revenue from the payroll tax. We further explore how changes in the personal income tax interact with revenues from other tax bases, exemplified by estimates of increases in indirect tax revenues. The last section summarizes results.

II. MORE AMBITIOUS SCORING PROCEDURES

Dynamic scoring refers to revenue estimation procedures that take into account agents’ reactions to tax changes; see Auerbach (2005) for a discussion of the pros and cons of dynamic scoring. Obviously, ignoring such reactions could distort revenue estimates as important effects are neglected. Such procedures are also politically biased, because tax cuts may seem more costly than they really are. However, as noted by Gale and Orszag (2005), tax cuts do not necessarily lead to increased national income and thereby increased revenues. Instead, the results will depend on how the government closes the budget deficit, for example, whether the initial reduction in revenue is matched by a

---

1 The labor supply response to taxes, including the possibility that the supply curve of labor may be backward bending, is discussed further below.
reduction in government consumption. More generally, arguments against dynamic scoring stress substantial uncertainty about the magnitudes of behavioral effects, including the potential need for corresponding estimates for the expenditure side of the budget, the possibility that methodological assumptions would reflect political pressure, and various technical challenges, including the need for closer integration of baseline and dynamic scoring simulations.

Whereas the discussion of U.S. revenue scoring procedure reflects the U.S. system’s longer planning horizons, the Norwegian system concentrates mainly on the revenue of the coming year’s budget. Even from a short run partial equilibrium perspective, scoring of tax proposals that leaves out important behavioral effects, which is the current practice in Norway, is in danger of being misleading; see Thoresen, Aasness and Jia (2008) for details of the Norwegian revenue estimation system. But if a more sophisticated scoring procedure is to be utilized, which effects should be included?

Some researchers have tried to analyze potential effects systematically. Slemrod (1992, 1995) suggests a three-tier behavioral response hierarchy under which real responses are the most sluggish, timing is the most responsive, and the third component, avoidance behavior, is somewhere in the middle. Gravelle (1995) identifies three categories of responses: microeconomic effects and macroeconomic effects, with the latter subdivided into cyclical effects, such as those arising from an underemployed economy, and more permanent effects that increase or decrease productive resources (labor and capital). Microeconomic effects include behavioral responses affecting the allocation of consumption or investment, and changes in the timing and type of income received. In these terms, we are concerned primarily with short run real or permanent macroeconomic effects, such as labor supply effects and the associated effects on payroll tax revenues. In addition, we examine a mechanical revenue feedback effect — the increase in indirect taxes tax revenues due to higher disposable income which stimulates consumption and increases indirect tax revenue. Creedy and Duncan (2005) describe the first, second and third round revenue effects on labor supply of policy changes, with the first round assuming fixed hours, the second round reflecting changes in desired hours of work, and the third round considering changes in wages. We do not consider the third general equilibrium effect in our analysis. Instead, we focus on the difference between the first and second round effects.4

The main contribution of this paper is estimates of the short run self-financing ratio, or the fraction of the static revenue loss that is offset due to behavioral effects and tax interactions, for personal income tax cuts in Norway, using the 2006 Norwegian tax reform as an example. In terms of notation, we isolate the contribution of the different tax bases by using $lR$ for revenues from tax base, where $l = PI, PAY, IND$, so that $PIR$

---

2 For diverging views on effects of recent U.S. tax reforms, see Diamond (2005) and Gale and Orszag (2005).
3 See Congressional Budget Office (2003) and the Joint Committee on Taxation (2005) for more details on U.S. procedures.
4 Note that the literature deriving analytical expressions for tax revenue responsiveness is closely related to this paper (Hutton and Lambert, 1980; Creedy and Gemmell, 2005; Mankiw and Weinzierl, 2006).
is revenue from the personal income tax, \( PAYR \) symbolizes revenue from the payroll tax, and \( INDR \) is revenue from indirect taxes. Let \( IR_j \) indicate the effects included in revenue estimates, where \( j = N,L \), and \( N \) refers to revenue estimates without behavioral effects and \( L \) indicates the incorporation of labor supply effects. We define the overall offsetting effect (\( OOE \)) as the ratio of the sum of the various offsetting effects to the initial static or mechanical cost estimate (\( -\Delta PIR_N \)), where the counteracting effects are as follows: (1) the effects of labor supply adjustments on revenue from personal income tax, measured as the difference between personal income tax revenue losses with and without labor supply effects (\( \Delta PIR_L - \Delta PIR_N \)), (2) the effect on payroll tax revenue of labor supply adjustments (\( \Delta PAYR_L \)), and (3) the static effects on indirect tax revenue from the increased consumption made possible with higher disposable income, before labor supply effects (\( \Delta INDR_N \)), and (4) the increase in revenues due to the increased consumption associated with increased labor supply (\( \Delta INDR_L \)):

\[
(1) \quad OOE = \frac{(\Delta PIR_L - \Delta PIR_N) + \Delta PAYR_L + \Delta INDR_N + \Delta INDR_L}{-\Delta PIR_N}.
\]

One of the key dynamic revenue scoring issues in the U.S. is whether scoring procedures should incorporate macroeconomic feedback effects.\(^5\) While we ignore dynamic general equilibrium effects in our short-term revenue analysis, we argue that short run labor supply effects are relevant to the partial nature of our analysis. The framework in which we model labor supply behavior allows us to distinguish between short and long run labor supply adjustments. The short run effects can be identified by assuming that unobserved individual characteristics (represented by the error terms in the utility function) in the scoring of the effects of the 2006 tax system are identical to the error terms of the reference system, and then calculating effects for fixed choice sets; see Appendix for a detailed presentation of the labor supply model. We do not, however, consider other behavioral effects, for example on investment decisions.

### III. THE NORWEGIAN TAX REFORM OF 2006

Norway has a “dual income tax” system, enacted in a 1992 tax reform\(^6\) which consists of a combination of a low proportional tax rate on capital income and progressive tax rates on labor income. The system proliferated throughout the Nordic countries in the early 1990s.\(^7\) The Norwegian version had a flat 28 percent tax rate levied on corporate income, capital and labor income coupled with a progressive surtax applicable to labor

---

\(^5\) In that sense it may be misleading to refer to scoring procedures for given macroeconomic conditions as static, as they will normally include microeconomic behavioral effects (Auerbach, 2005).


\(^7\) The dual income tax was introduced in Sweden in 1991, in Norway in 1992, and in Finland in 1993. The idea originated in Denmark, where it was implemented in 1985.
income. Double taxation of dividends was abolished, as taxpayers receiving dividends were given full credit for taxes paid at the corporate level, and the capital gain tax system exempted gains attributable to retained earnings taxed at the corporate level. These separate schedules for capital and labor income created obvious incentives for taxpayers to recharacterize labor income as capital income. To limit such tax avoidance, the 1992 reform introduced the “split model” for the self-employed and closely-held firms (defined as businesses in which more than two-thirds of the shares were owned by the active owner). Rules were established for dividing business income into capital and labor income, and the resulting imputed wage income was subject to a two-tier surtax. The top marginal tax rates for wage earners and owners of small businesses (the self-employed and owners of closely-held firms) were 48.8 percent and 51.7 percent in 1992. Between 1992–2004, both the threshold for the second tier of the surtax and marginal rates increased, resulting in the statutory tax rates for 2004 shown in Figure 1. The top marginal statutory tax rates for high income wage earners was 55.3 percent in 2004, and the schedule for imputed wage income under the split model (not shown in Figure 1) has a very complicated structure, implying highly non-convex budget sets, with marginal tax rates moving from 52.2 through 49.3, 28.0, to 55.3 percent, and then back down to 28 percent again as income increases.

The 1990s saw increasing pressure on the dual income tax system, resulting in numerous “patches.” As these were not entirely successful, the reform of 2006 emerged as an attempt to create a system that would prevent taxpayers from transforming labor income into capital income to benefit from the lower flat rate applied to the latter. Successful businesses found it advantageous to move out of the split model.

Under the 2006 tax reform, the split model was superseded by rules of a more general nature, with dividends taxed at both the corporate and individual levels, in contrast to the 1992 reform which had only corporate level taxation. The current tax is levied on individual dividend incomes above a rate of return allowance, that is, on profits above a risk-free rate of return.10

Important to note for present purposes, marginal tax rates on wages were cut to narrow the differences between the marginal tax rates on capital income and labor

---

8 The rates for business owners were higher because social insurance contribution rates were higher, 10.7 percent rather than 7.8 percent. However, under the split model, for imputed wage income above NOK434,000 (US$70,000 according to the exchange rate for 1992), the social security tax goes down to 7.8 percent for business owners as well.
9 See Sørensen (2005) for the wider background to the reform and steps taken to adjust the dual income tax system.
10 Obviously, this tax change influences behavior. In 2004 prior to the reform, dividends of about 60 billion Norwegian kroner (NOK), corresponding to about 9.75 billion U.S. dollars, were transferred to Norwegian households. In 2006, dividends fell to NOK18 billion (US$2.9 billion). This estimate, provided by the Ministry of Finance, includes timing effects, reflecting an increase in dividends prior to the enactment of the shareholder tax. This example also highlights the importance of focusing on different tax bases simultaneously, as the reduction in dividends will be reflected in increases in retained earnings, influencing corporate tax revenues.
income. Figure 1 reflects the principal features of the Norwegian labor income tax system: a two-tier surtax that supplements a basic income tax rate of 28 percent plus a 7.8 percent social insurance contribution. In 2004 the first tier of the surtax was applied at approximately NOK380,000 (US$59,200)\textsuperscript{11} at a rate of 13.5 percent, and the second tier of 19.5 percent applied to income in excess of approximately NOK970,000 (US$151,100).\textsuperscript{12} In the 2006 reform, the maximum marginal tax rate fell from 55.3 to 47.8 percent, but became effective at a lower level of NOK800,000 (US$124,600). To sum up, the reform effected a dramatic realignment of the maximum marginal tax rates on capital income in excess of the risk-free rate of return and wage income, from 28 and 55.3 percent respectively in 2004, to 48.2 percent and 47.8 percent in 2006.\textsuperscript{13} Such cuts might be expected to have substantial labor supply effects, an issue to which we will

\textsuperscript{11} We use an exchange rate of one US$1 for 6.418 Norwegian kroner (NOK), the average exchange rate in 2006.

\textsuperscript{12} All thresholds are adjusted to 2006 levels.

\textsuperscript{13} The figure for the marginal capital tax rate in 2006 is derived as follows. Capital income is taxed at a 28 percent rate at the corporate level, and the remaining 72 percent is transferred to the individual and taxed at 28 percent (above the rate of return allowance), resulting in a combined rate of 20.16 percent (0.72 x 0.28), which is then added to the corporate level rate.
return shortly. Since the reform also increased the level of capital income taxation, one might expect a negative impact on investment decisions and tax revenues by extension. However, as argued by Sørensen (2005), the new scheme of shareholder taxation is not expected to affect investment incentives since only inframarginal returns are subject to tax. In any case, the one-year time horizon is probably too short for the revenue effects of altered investment behavior to appear. In the longer term, revenues may increase due to this element of the tax reform, as it reduces income shifting incentives and taxes inframarginal returns at a higher rate.

In order to mitigate the distributional problems associated with the reform, the government increased the wage income standard deduction, which is constructed by multiplying wage income by a factor (equal to 24 percent in 2004) subject to a maximum (NOK50,780 or US$7,900, in 2004, in terms of wage-adjusted 2006 kroner). In 2006 the multiplicative factor increased to 34 percent, and the maximum deduction increased to NOK61,100 (US$9,500).14 There were some other changes as well, and the tax on income generated by owner-occupied homes was phased out.

As we will also be considering revenue effects attributable to changes in indirect taxation and payroll taxes, we briefly describe these two elements of Norwegian tax system. The system of indirect taxation consists of a VAT and various excise taxes. The basic value added tax (VAT) rate is 25 percent, though there are exceptions, most notably on food (13 percent). Some goods are subject to excise duties, including alcoholic beverages, tobacco and gasoline, and marginal effective tax rates vary widely; for example, the effective tax rate on food is 0.111, whereas the effective tax rates on the purchase of spirits, wine, beer, and tobacco are 0.715, 0.590, 0.688, and 0.645 respectively. These rates are tax-inclusive, that is, they are measured as shares of consumer prices.

The Norwegian payroll tax (or employers’ social security contribution) is differentiated by five geographical zones. In 2006, 14.1 percent of gross labor income was charged in zone 1 (representing 77 percent of the population). It decreases in the other zones according to their remoteness from zone 1, ending with a zero tax rate in zone 5. The estimate for the average payroll tax is 13.2 percent for 2006.

IV. REVENUE ESTIMATING METHODOLOGY

Our benchmark revenue estimate of the effects of the 2006 reforms uses the non-behavioral LOTTE-Skatt model to simulate revenues under the 2004 and 2006 personal income tax schedules.15 This mechanical approach estimates the overall cost of the reform as $\Delta PIR_N = $NOK 9.3 billion (US$1.44 billion); for completeness, Table 4 provides details on how the tax reductions are distributed among households at different income levels. Note that the revenue cost of NOK9.3 billion was 0.43 percent of GDP and 1.29 percent of total mainland tax revenue (exclusive of petroleum taxes) in 2006.

---

14 These largely inframarginal changes should have a limited effect on labor supply.

15 This model and the other simulation models used in our study are described in the Appendix.
As discussions in the United States have revealed, the economic effects of tax reforms that have non-neutral revenue effects depend on how the budget is balanced (Diamond, 2005; Gale and Orszag, 2005; Leeper and Yang, 2008). We do not discuss effects from the financing of the tax cuts, however, since Norwegian reforms can be seen as funded by borrowing against future income, transferring money from the Norwegian Pension Fund, a fund based on Norwegian oil wealth. Although interest rates may rise as a result and affect tax revenues, we neglect these effects in our analysis.

We turn next to a discussion of factors that act to reduce the revenue loss of the tax cut, that is, the extent to which the tax cuts might be self-financing.

A. Labor Supply Effects

Much empirical research suggests significant positive labor supply responses to increases in after-tax wages (Blundell and MaCurdy, 1999; Kniesner and Ziliak, 2008; Meghir and Phillips, 2008). This suggests that ignoring the labor supply effects of taxation exaggerates the revenue losses associated with cuts in labor income taxation. In this section we discuss the effect on revenues of including labor supply responses, using the sub-module LOTTE-Arbeid (Dagsvik and Jia, 2008) of the LOTTE modeling system.

The LOTTE-Arbeid simulation model is based on three separate micro data estimates: a joint model for married couples and two separate models for single females and males. The Appendix explains the modeling framework and estimation results. Estimated uncompensated wage elasticities are approximately 0.60 for married/cohabiting females, 0.08 for married/cohabiting males, 0.04 for single females, and 0.03 for single males. These elasticities are similar to the values Evers, de Mooij, and van Vuuren (2005) report as median estimates for males and females in their meta analysis of labor supply elasticities. For example, a point estimate of 0.60 for married/cohabiting females is higher than the estimates of 0.25–0.34 found by Heim (2009), found for married females in the United States, but smaller than the estimates ranging from 0.47–1.03 found by van Soest (1995) using Dutch data. The elasticity estimate of 0.08 for married/cohabiting males is very close to many studies, including Blomquist and Newey (2002) and Heim (2009) for U.S. married males and van Soest (1995) for Dutch married males. It is, however, generally difficult to compare elasticity estimates across countries. In particular, when models are non-linear (like ours), tax and transfer system variations and differences in

---

16 According to fiscal policy guidelines, in order to bring petroleum revenues into the economy, the government’s non-oil budget deficit should correspond to the real return of the Government Pension Fund, estimated at 4 percent.

17 Carroll and Hrung (2005) and Feldstein (2008) argue that estimates of the taxable income elasticity are relevant in this context, as they reflect a broad range of responses to tax changes, rather than only hours worked. Accordingly, instead of using a labor supply simulation model, we could have used the taxable income elasticity estimates for Norway of Aarbu and Thoresen (2001). For example, using a taxable income elasticity of 0.2 (one of their central estimates), we estimate an overall tax revenue offset — based on calculations of the reform-induced income growth factors at different levels of wage income, multiplied by the elasticity estimate — of 58 percent, which is quite similar to the benchmark estimate derived below.
attachment to the labor market across countries may contribute to diverging elasticity estimates. But inelastic labor supply for males and moderate positive elasticities for married females are in accordance with the literature (Blundell and MaCurdy, 1999; Kniesner and Ziliak, 2008; Meghir and Phillips, 2008). For instance, Blundell and MaCurdy note that estimates of uncompensated elasticities for married women range from −0.01–2.03 with a median of 0.77, while Kniesner and Ziliak (2008) stress differences between the extensive margin and intensive margin elasticities for females, suggesting that the former exceeds 1.0 and the latter (for women with no attachment to the welfare system) being close to that found for prime-age married males.

The discrete choice labor supply model assumes that utility-maximizing individuals choose from a set of work alternatives (jobs in our setting). Individual behavior is determined by the relative ranks of these alternatives. A change in tax rules will generate a change in the individual’s post-tax income under each alternative, and may influence the ranking of alternatives and lead to a change in labor supply behavior. We want to score the difference in labor supply between a reference system (or a baseline), in our case the 2004 tax law, and the 2006 tax law, focusing on consequences for next year’s budget. The short-term perspective of our analysis introduces two model features. First, unobserved individual characteristics (represented by the error terms in the utility function) in the scoring of the effects of the 2006 tax system are identical to the error terms of the reference system. Second, job opportunities under the new tax schedule are also similar to the baseline situation. We argue that these two characteristics are consistent with a short run perspective. As noted in the literature, tax policy changes influence many dimensions of individual labor supply decisions, including hours of work, participation, specific human capital accumulation, occupational choices, etc. Saez (2004) argues that taxpayers may not be able to adjust all these aspects right away, so that some of the responses may be lagged. In particular, in the short run, it is difficult for taxpayers to adjust factors other than hours of work and perhaps participation behavior. In the long run, taxpayers can react to tax policy changes by changing their occupational choices and location of work, as well as hours of work. It has been argued in the literature that labor supply is quite inelastic on the intensive margin (hours of work). This is partly confirmed by Blundell, Brewer and Francesconi (2008), who find that working hours are quite inflexible within a given job. However, they also note that the labor supply of single mothers increased on average by about 4.5 hours per week shortly after the introduction of the Working Families Tax Credit, primarily due to movements between jobs. Since job choice is the key decision variable in our framework, the model is consistent with such observations.

In the context of our labor supply model, the latent individual-specific choice set of jobs and unobserved characteristics should be exogenous in the short run, though the choice sets and some household attributes may change over the longer term as individuals acquire new skills, relocate, etc. Ignoring choice constraints in labor supply modeling will most likely overestimate peoples’ responsiveness to tax changes.  

18 Using Belgian data, Dagsvik, Orsini and Jia (2008) find that a model that ignores choice constraints predicts much higher elasticities than a model with choice constraints.
the modeling framework is especially suitable for differentiating short and long-run revenue-estimating horizons.

As noted above, we keep the error terms constant in the baseline simulation; this approach follows Creedy and Kalb (2005). We start from the baseline and predict the labor supply responses conditional on baseline behavior. First, we draw a set of random variables from the relevant distributions (in our case, the extreme value type I) and calculate the total utility (including the error term) for each alternative. If the alternative with the highest utility level happens to be the baseline labor supply choice, we accept the draw; otherwise we draw another set of error terms. Thus, it is guaranteed that the accepted set of error terms will always lead to the baseline labor supply behavior. The same sets of error terms for each household are then used in the simulation of the effects of the alternative tax schedule (scoring), in which case only the deterministic part of the utility functions changes, and new respective (stochastic) realizations for each household’s optimal labor supply behavior follow. Based on 200 draws we get a probability distribution across hours of work. By taking expectations we obtain estimates of taxes paid, hours of work, pre-tax income, etc., for the post-reform tax schedule.

As expected, employing the labor supply model simulations reduces the estimated revenue costs of the reform. The estimated reduction is from approximately NOK9.3 billion (US$1.44 billion) to NOK6.5 billion (US$1 billion). The offsetting effect ratios for the personal income tax and the payroll tax revenues (the effect on indirect tax revenues will be presented below) are shown in Table 1, calculated as the increased revenue generated by the labor supply effect divided by the initial static or mechanical estimate ($\Delta PIR_N$). Approximately 34 percent of the initial personal income tax revenue reduction is offset by labor supply adjustments, measured by taking the difference between $\Delta PIR_N$ and $\Delta PIR_L$ and dividing by $\Delta PIR_N$. This estimate obviously depends on a wide

<table>
<thead>
<tr>
<th>$\Delta PIR_N$</th>
<th>$\Delta PIR_N - \Delta PIR_L$</th>
<th>$\Delta PAYR_L$</th>
</tr>
</thead>
<tbody>
<tr>
<td>-9,272</td>
<td>0.34</td>
<td>0.12</td>
</tr>
</tbody>
</table>

Another tax simulation procedure for discrete choice models used in practical work is based on predictions of labor supply behavior ignoring individual level information about error terms and only employing the sample information on probabilities (Kornstad and Thoresen, 2007). This assumption can be partly justified by claiming that the random error terms are not only unknown to the economist, but also to the household themselves (Dagsvik and Jia, 2008).

Measuring the labor supply offsetting effect in terms of the static revenue change for wage earners only yields roughly the same offsetting ratio.
variety of factors in the current example, including the specific composition of the tax reform,\textsuperscript{21} demographic factors, the distribution of income, etc. as well as the validity of the labor supply model and the accuracy of parameter values. Nevertheless, the analysis provides an indication of the magnitude of this effect. Interestingly, a one-third revenue offset is quite close to what Feldstein (2008) reports for a labor income tax increase in the United States; his analysis employed a technique based on information from difference-in-differences estimates of taxable income elasticities.\textsuperscript{22}

Given the rather modest labor supply elasticities of our labor supply model noted above (see also the Appendix, in particular Table A2), the magnitudes of these effects may seem surprising. There are several possible explanations. As the model is non-linear, it may be misleading to infer effects from average elasticity estimates, given that initial tax rates are quite high. Also, the 2006 Norwegian reform had a highly disproportionate effect on high income households, where initial tax rates were high and tax rate reductions were rather large (Figure 1), making a large labor supply response at high income levels more likely. Note that these results suggest that labor supply curves in Norway are not backward bending.

We also examine the sensitivity of the results with respect to variations in labor supply elasticities. As described in the Appendix, the labor supply elasticities utilized are derived by simulation methods, so it is not particularly easy to obtain alternative labor supply elasticity estimates. Nevertheless, we calculate tax revenue estimates for a low-response scenario and a high-response alternative using bootstrap techniques for constructing confidence intervals for the model parameters. That is, we resample the dataset with replacement (200 draws), and estimate our model using these resampled datasets. Using this technique, we can obtain the approximate distributions of the model parameters and aggregate labor supply elasticities. In Table 2 we report two new sets of labor supply elasticities — a low-response alternative, based on the combination of parameter values generating the lowest elasticities, and a high-response alternative based on the largest response obtained; the benchmark parameter values used above are included as well.

The revenue offsets corresponding to these alternative labor supply estimates are shown in Table 3, and range from 39 percent in the high-response case to 27 percent in the low-response case.

Reform-induced changes in labor supply affect more than just personal income tax revenues. As pre-tax incomes rise, the revenue from the payroll tax will be affected, and since post-tax incomes and consumption are rising, indirect tax revenue is also affected by changes in labor supply. We briefly present the payroll tax effects, and describe in the next subsection the contributions from indirect tax revenues. Note that the implications of payroll tax revenue are also noted by Feldstein (2008) in his dis-

\textsuperscript{21} In fact, this problem can be alleviated by decomposing the effects of reform into the effects of increases in standard deductions, reductions in marginal tax rates, etc. (Finansministeriet, 2002).

\textsuperscript{22} See also the estimates of Carroll and Hrung (2005). They control for income shifting, which as already noted is also relevant in the Norwegian case.
### Table 2

#### Alternative Estimates of Labor Supply Elasticities

<table>
<thead>
<tr>
<th>Couples</th>
<th>Males, Hours of Work</th>
<th>Females, Hours of Work, Conditional on Working</th>
<th>Females, Hours of Work, Unconditional</th>
<th>Single females Probability of Working</th>
<th>Single females Hours of Work</th>
<th>Single Males Hours of Work</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low-response set</td>
<td>0.0473</td>
<td>0.2060</td>
<td>0.4930</td>
<td>0.0055</td>
<td>0.0124</td>
<td>0.0140</td>
</tr>
<tr>
<td>Benchmark set</td>
<td>0.0770</td>
<td>0.2790</td>
<td>0.6120</td>
<td>0.0300</td>
<td>0.0230</td>
<td>0.0400</td>
</tr>
<tr>
<td>High-response set</td>
<td>0.0920</td>
<td>0.3480</td>
<td>0.7290</td>
<td>0.0808</td>
<td>0.0516</td>
<td>0.0907</td>
</tr>
</tbody>
</table>
discussion of the revenue effects of a labor income tax increase in the United States. In order to simplify the calculations, we employ an estimated average payroll tax rate in 2006 of 13.2 percent. An estimate of the additional revenue from the payroll tax (for unaltered corporate profits) because of labor supply adjustments, $\Delta PAY RL$, is derived by multiplying this rate with the increase in gross income, according to labor supply model simulations; this results in a revenue offsetting effect of approximately 12 percent, as seen in Table 1.

### B. Revenue Effects through Increased Consumption

We now discuss the effects on indirect tax revenues of the reduction in personal income tax rates. The effects on indirect taxes have two sources: (1) a direct effect that follows directly from increased consumption enabled by reform-induced increases in disposable income, before any labor supply effects, and (2) an indirect effect due to the increase in consumption driven by higher incomes due to increased labor supply. Official estimates of the revenue effects of tax changes in Norway, which are produced for every change in the personal income tax, do not reflect such interactions with other tax bases. In contrast, macro predictions of the economy, such as those provided by the macroeconometric model MODAG (Boug et al., 2002), do take these interactions into account, as the disposable income of the household sector increases in response to a reduction in personal income tax rates. Similarly, macro predictions reflect changes in labor supply due to lower marginal and average tax rates. In a similar vein, we want to identify such effects stemming from a particular tax change and relate them to estimates of revenue costs. More generally, since personal income tax cuts are likely to increase consumption rates and indirect tax revenues, budget estimates should arguably reflect them. Of course, the same approach should be utilized with respect to the financing of the tax cuts, an issue that is ignored in this analysis.

---

23 See the description of the actual payroll schedule in the previous section.

24 Note that any effects on indirect tax revenues in the United States would almost entirely be limited to the states.
Before turning to our estimates of indirect tax revenue effects, consider some statistics on indirect tax revenues for the period under consideration. Of course, raw data on actual indirect tax revenue developments do not represent any evidence of reform-induced behavior. Nevertheless, indirect tax revenues increased substantially over the period 2004–2006, with VAT tax revenues increasing from about NOK137 billion (US$21.3 billion) in 2004 to about 150 billion (US$23.4 billion) and 169 billion (US$26.3 billion) in 2005 and 2006.25 The inflation rate was low at the time, approximately 3.9 percent. Increasing the general VAT rate from 24 to 25 percent and the VAT rate on food from 12 to 13 percent in 2005 may have resulted in larger VAT tax revenues, but it is interesting to note that revenue grew more between 2005–2006, when the VAT remained unchanged, than after the rate increase in 2005. At a minimum, the evidence on actual indirect tax revenues does not suggest that people did not use higher post-tax income to consume more.

To fix ideas, note that household $i$’s contribution to indirect tax revenues ($\Delta IND R_i$) from an increase in post-tax income is determined by the product of total consumption expenditures (the change in after-tax or disposable income, $\Delta DIS P_i$, multiplied by the marginal propensity to consume, $M P C_i$) and the effective marginal indirect tax rate, $M I T R_i$,

\[(2) \quad \Delta IND R_i = \Delta DIS P_i \cdot M P C_i \cdot M I T R_i.\]

The calculation of the marginal tax rate, $M I T R_i$, is given by

\[(3) \quad M I T R_i = \sum_{g \in G} t_g w_{ig} e_{ig},\]

where $g$ stands for commodity group $g$, $G$ is the set of all commodity groups, $t_g$ is the tax rate for commodity $g$ including VATs, excise taxes, and adjusted for subsidies, $w_{ig}$ is the budget share of commodity $g$ for household $i$, and $e_{ig}$ is the Engel elasticity for commodity group $g$ for household $i$. Note that the tax rates ($t_g$) and $M I T R$ are measured as a percentage of consumer prices. Thus, for a country with a VAT of 25 percent on all commodities, and no excise duties or subsidies, $t_g$ and $M I T R$ are equal to 0.25/1.25 = 0.2.

In the LOTTE-Konsum model, the (aggregate) marginal propensity to consume is determined endogenously, based on exogenously given estimates of total consumption, but model results can be recalibrated to give alternative MPCs. Ideally, we should have estimated the $M P C$s individually, allowing for saving to be dependent on income and other variables. Unfortunately, that is impossible in the present version of the LOTTE-Konsum model. The overall marginal propensity to consume out of post-tax income may depend on the current macroeconomic situation, including consumers’ expectations of future income. In the present paper we use $M P C = 0.7$ as our main estimate, but we also calculate revenue effects for $M P C = 0.5$ and $M P C = 0.9$ for the purpose of sensitivity check.

---

25 These estimates are derived from data provided by Statbank of Statistics Norway (http://statbank.ssb.no/statistikkbanken/?PLanguage=1).
The effective tax rates for the 30 commodities are derived from the CGE MSG model (Heide et al., 2004). These tax rates vary, partly because of variation in excise taxes. Note that since different households have different budget shares and Engel elasticities for a given commodity group, the marginal tax rate, MITR, is household specific and depends on the pre-reform disposable income. As already noted, taxpayers will experience changes in their post-tax incomes because of reduced tax burdens with fixed labor supply (the direct effect) and also because they will alter their labor supply in response to the new tax schedule (the indirect effect). Denote the after-tax income for household $i$ in the reference system (baseline) as $D_i^*$ and the after-tax income for household $i$ under the alternative tax schedule as $D_i^{**}$. Then the expected contribution to indirect tax revenues from the labor supply adjustment of household $i$ is

$$E(\Delta INDR_i) = E[MPC_i \cdot MITR_i \cdot (D_i^{**} - D_i^*)] = MPC_i \cdot MITR_i \cdot (ED_i^{**} - D_i^*)$$

This convenient estimate of the revenue effects from labor supply adjustments follows from the chosen simulation approach, as unobserved individual characteristics are assumed to be fixed in the short run. Alternative simulation approaches, as the one referred to in footnote 19, would require a much more complicated procedure, involving calculations for each possible combination of hours of work in the post-reform and pre-reform systems.

Households in the databases of LOTTE-Skatt and LOTTE-Konsum are ranked according to household income and grouped into deciles. Multiplying the tax rate by the increase in after-tax income generates an estimate for each household’s contribution to the change in indirect tax revenue following the 2006 tax cuts. In Table 4, we report aggregated values across deciles both for the changes in after-tax incomes and the changes in revenues.

The offsetting effects ratios for the reform-induced changes in indirect tax revenues ($\Delta INDR_j$) are presented in Table 5. Approximately 12 percent of the initial static revenue estimate is recouped from the direct effect of the 2006 reform ($\Delta INDR_N$), and an additional 6 percent is recouped as a result of the labor supply adjustments following the reform ($\Delta INDR_L$).

### C. Estimates of The Short-Term Self-Financing Ratio for Personal Income Tax Cuts

The revenue effects addressed in this paper are summarized in Table 6. Recall that the overall revenue offsetting effect or short-term financing ratio is defined as:

$$[(\Delta PIR_L - \Delta PIR_N) + \Delta INDR_N + \Delta INDR_L + \Delta PAYR_L] / (-\Delta PIR_N).$$

In our benchmark case (in bold in Table 6), we obtain an estimate for OOE of 64 percent of the initial revenue cost estimate — that is, with $MPC = 0.7$ and the benchmark estimates of labor supply elasticities. The degree of self-financing in this case is therefore more
than 60 percent. Of course, as noted previously, this estimate depends on a wide variety of factors, not the least of which is the accuracy of the models and parameter values utilized. Nevertheless, we are convinced that such estimates are closer to the actual revenue costs of personal income tax cuts than those obtained with static revenue estimation. Table 6 also presents estimates from a number of calculations under alternative MPCs and alternative assumptions about labor supply responsiveness. For instance, with high-response labor supply and a high MPC (0.9), the overall rate of self-financing is 0.76, whereas it declines to 0.48 for the combination of low-response labor supply and low MPC (0.5).
### Table 6
Summary of Revenue Offsetting Effects

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Low response</td>
<td>0.5 0.27 0.09 0.04 0.09 0.48</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.7 0.27 0.12 0.05 0.09 0.53</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.9 0.27 0.15 0.06 0.09 0.58</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Benchmark: middle response</td>
<td>0.5 0.34 0.09 0.05 0.12 0.59</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.7 0.34 0.12 0.06 0.12 0.64</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.9 0.34 0.15 0.08 0.12 0.70</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High response</td>
<td>0.5 0.39 0.09 0.05 0.13 0.65</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.7 0.39 0.12 0.07 0.13 0.70</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.9 0.39 0.15 0.09 0.13 0.76</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
V. CONCLUDING REMARKS

This paper attempts to quantify the difference between revenue estimates obtained according to current “static” revenue estimating procedures in Norway and more ambitious methods, using the 2006 tax reform as an example. Once the effects from labor supply responses are considered, the revenue cost of the 2006 reform is substantially reduced. The paper also demonstrates the benefit of including effects on other tax bases as well. Lower personal income taxes will affect consumption tax revenues and labor supply responses will affect payroll tax revenues. All in all, roughly 60 percent of the static revenue cost of the reform is estimated to be recouped when we take these effects into account.

Obviously, the robustness of this estimate of the extent to which personal income tax cuts are self-financing to the inclusion of other effects is unresolved. In addition, the results do not address the effects of steps that might be taken to balance the budget including any expenditure side effects of policy changes. Tax cuts generally need to be offset by spending cuts, and many changes in expenditures may have substantial indirect effects on tax revenues. For instance, changing state health benefits will affect labor supply, and changing child care subsidies will affect the labor supply of parents of preschool children. Thus, more realistic estimates would consider both changes in budget expenditures and incomes (and their interaction), as well as behavioral effects. These demanding extensions require high quality modeling tools, and should be fruitful grounds for future research.

ACKNOWLEDGEMENTS

We would like to thank Kirsten Hansen, Bård Lian and Odd E. Nygård for their assistance in the preparation of this study, and Erling Holmøy, the editor and two anonymous reviewers for comments on an earlier version of the paper. Comments from participants at the 8th Nordic Seminar of Microsimulation Models, June 8–9, 2006 in Oslo, at a seminar at the Tax Policy Department at the Ministry of Finance, September 13, 2007 in Oslo, and at the Labour Institute for Economic Research, February 27, 2008 in Helsinki, are appreciated.

REFERENCES


Joint Committee on Taxation, 2005. “Overview of Revenue Estimating Procedures and Methodologies Used by the Staff of the Joint Committee on Taxation.” Publication JCX-1-05. Joint Committee on Taxation, Washington DC.


APPENDIX: DESCRIPTION OF THE SHORT-TERM MICROSIMULATION MODEL SYSTEM

The tax-benefit LOTTE model is a microsimulation model developed to predict the distributional and revenue effects of changes in the taxation of individuals in Norway; see Aasness, Dagsvik and Thoresen (2007) for further details. The model is static in the sense that it is developed to simulate short-term effects, in contrast to the dynamic microsimulation model MOSART (Fredriksen and Stolen, 2007), which is capable of performing long run simulations.

The LOTTE model system currently consists of three modules: (1) a module for simulating personal income taxes, LOTTE-Skatt, (2) a module for simulating indirect taxes, LOTTE-Konsum, and (3) a module describing the labor supply effects of changes in the personal income tax, LOTTE-Arbeid.

A1. The Tax-benefit LOTTE-Skatt Model

The first version of the LOTTE-Skatt model was developed early in the 1970s. It has proved extremely popular with Norwegian policy-makers, and has been a key tax policy tool over the last few decades. The model allows no behavioral responses to taxation. The Ministry of Finance uses the model throughout the year for drafting the annual budget which is put forward in early October. When the Government tables the bill, the other political parties in Parliament use the model to compute the effects of their own budget alternatives.

The LOTTE-Skatt model consists of four parts: (1) individual income data, (2) a program that projects data to the year of interest, (3) a set of tax rules, and (4) a simulation routine that applies the tax rules to individual records. Standard model results include estimates of the aggregate revenue effects and distributional effects of various policies.

The model’s main source of data is individual income tax returns. Income tax return data are now electronically available for all citizens. However, as many questions concerning income and taxes are best understood at the household level, we need to construct households from the individual data. We used to obtain household information from sample surveys. However, since the tax year 2005, we use the national register of ground addresses and buildings to obtain information on the composition of households. This allows us (in principle) to simulate tax burdens for the whole population. However, in order to reduce computing time, we run the model for a 10 percent sub-sample. The present analysis is based on data on about 34,000 persons or 13,000 households for the year 2004.

We use macroeconomic predictions for income growth, income composition, etc. to project the data forward. These estimates are computed in close collaboration with the Ministry of Finance, with the help of Statistics Norway’s macro models.

Detailed tax rules for different years are compiled in the tax law module of the model. It is easy to introduce simple changes to the tax rules, such as changes in statutory tax rates or deductions. For more advanced tax system changes, we usually have to change the simulation routine as well. The simulation routine applies the tax rules to household data to predict the effects of reforms.

A2. The Short-term LOTTE-Arbeid Model of Labor Supply Effects

There is no consensus in the literature regarding the best way to model the relationship between labor supply and taxes (Blundell and MaCurdy, 1999; Meghir and Phillip, 2008). We use the labor supply model developed by Dagsvik and Strøm (2006) and Dagsvik and Jia (2008), which is based on a particular discrete choice framework proposed by Dagsvik (1994). Insofar as it gives fundamental importance to the notion of job choice, this approach differs from standard discrete choice models of labor supply. A job is characterized by fixed (job-specific) working hours and other non-pecuniary attributes. The worker is assumed to have preferences over a latent set of jobs
from which he chooses his most preferred job. The choice set may vary across individuals due to differences in education, labor market experiences, occupational specific skills, and location of residence. There are several reasons why we chose this particular model, rather than other popular models in the literature. First, it was developed using a discrete choice framework, which obviates the need for marginal calculations and enables us to incorporate taxation and social security details (van Soest (1995); Creedy and Kalb (2005)). Note that standard labor supply models require the calculation of the budget set for each individual. Given the complexity of the taxation and social security systems, this can be rather cumbersome and impractical (Bloemen and Kapteyn, 2008). Discrete hours models are much easier to utilized since utility must be evaluated only at a small number of points. Second, the approach attaches fundamental importance to the notion of job choice and explicitly takes the individuals’ choice restrictions into account. Last but not least, the model is empirically practical with moderate data requirements and computational burdens.

Although we estimated models for married couples, single men and single woman separately, in the following discussion we consider only the single-person household. Individuals are assumed to choose from a set of jobs denoted by index $k$. Job $k$ has fixed working hours $H_k, H_k \in Q$, where $Q$ is the set of feasible hours of work. The wage rate is assumed to be specific to the individual and is denoted as $w$. For a given number of hours of work $h$, $B(h)$ denotes the agent’s set of available jobs with hours of work $h$, i.e. $B(h) = \{ k | H(k) = h \}$. We denote the number of jobs in $B(h)$ as $m(h)$. For the non-market alternative one can normalize such that $m(0) = 1$.

Let $U(C_k, H_k, k)$ be the utility function of the household, where $C_k$ denotes household consumption (post-tax income) and $k$ accommodates the notion that workers may have preferences for job types in addition to income and hours of work. For given job $k$, the economic budget constraints is given by

$$ (A1) \quad C_k = H_k w + I - t(H_k w, I), $$

where $t(H_k w, I)$ is the tax function, and $I$ denotes non-labor income. All of the details of the tax system and social security rules are taken into account in this function.

We assume that the utility function has the form

$$ (A2) \quad U(C_k, H_k, k) = v(C_k, H_k) \xi(k), $$

where $v(\cdot)$ is a positive deterministic function and $\xi(k)$ is a positive random taste shifter. Let $q(h|w, I, t)$ denote the probability of the agent choosing a particular job with advertised hours $h$, given the wage rate $w$, non-labor income $I$, and the tax rules represented by function $t$. Under the assumption that the error term, $\xi(k)$, follows an extreme value distribution of type 1, it can be shown that

$$ (A3) \quad \phi(h | w, I, t) = \frac{v(hw + I - t(hw, I), h) m(h)}{\sum x v(xw + I - t(xw, I), h) m(x)}. $$

The probability of the agent choosing a job with working hours $h$ thus has a relatively simple form. It is analogous to a multinomial logit model with representative utility terms $v(hw + I - t(hw, I), h)$ weighted with the relative frequencies of feasible jobs. Unfortunately, since $m(h)$ (number of jobs) is not directly observable, we can often only identify the product $v(C, h)m(h)$ nonparametrically. Parametric/functional form assumptions on $v(C, h)$ and $m(h)$ are required for estimation and simulation of the model. In the LOTTE-Arbeid module, the structural part $v(C, h)$
is specified as a function of observable personal attributes such as age and number of children, and is of the form,

$$\log(v(C, h)) = \alpha_2 \left( \frac{10^{-4} (C - C_0)^{\alpha_4}}{\alpha_1} - 1 \right) + \beta \left( \frac{(L - L_0)^{\alpha_3}}{\alpha_3} - 1 \right),$$

where $\beta = \alpha_5 + \alpha_6 \log A + \alpha_7 (\log A)^2$ and $C_0$ is the subsistence income level, which we have chosen to be NOK40,000 (US$6,200), $L$ is leisure, with $L - L_0 = 1 - h/3650$, and $A$ is age; see Dagsvik and Jia (2008) for a detailed discussion of model specification.

Three versions of the model are estimated using a sample of Norwegian microdata from 1997: a joint model for married couples and two separate models for single females and males. For practical purposes in the estimation of the model, we need to limit the choices of working hours: females choose between eight intervals of working hours, whereas males choose between seven. Table A.1 shows parameter estimates for the three models.

In contrast to traditional labor supply models, the discrete choice framework does not generate a standard labor supply function, where hours of work simply can be seen as a function of wage, non-labor income and other characteristics. Instead, the discrete model provides estimates of preference parameters but not estimates of the labor supply elasticities in the traditional sense. However, we can still use the concept of the wage elasticity of labor supply to describe the impact of wage rate changes on labor supply behavior, that is, how the mean of the distribution of labor supply is affected by changes in wage levels. For each household we simulate the change in the choice probabilities of working and the expected hours of work in response to a 10 percent increase of wage income; we then aggregate over the sample to obtain the corresponding change in the mean probability of working and mean expected hours of work. To obtain labor supply elasticities, we multiply these figures by 10 and divide by the respective mean probability of working and the mean expected hours of work. This measure depends on the distribution of the initial wage rate and the individual’s characteristics, as well as the tax and benefit system. Aggregate wage elasticities are calculated for all model versions. Due to the very high participation rate for males, we abstract from their participation decisions and consider only households where the male is working. The elasticities indicate a moderately elastic labor supply for married females, but much less elastic response for males and single females, consistent with the main findings in the literature (Blundell and MaCurdy, 1999; Meghir and Phillips, 2008). The overall wage elasticities with respect to working hours are 0.6 and 0.04 for married/cohabiting and single females, respectively, and the estimates for married/cohabiting and single males are 0.08 and 0.03, respectively. For married females the own wage elasticity of the probability of working is equal to 0.33, which means that if the wage rates of married females increase by 5 percent, the aggregate fraction of married females who work will increase by 1.5 percent. If the wage rate of the female and the male increases, the corresponding elasticity of the probability of working is equal to 0.22. Conditional on working, the wage elasticity of mean hours of work is equal to 0.28 for married females. We also note a slight fall in the elasticities conditional on income groups by income for females, but a slight increase for males. However, the elasticities with respect to a

\[26\] We also tried a specification including an interaction term between income and leisure, but the estimated parameter was not significantly different from zero.
### Table A1
Parameter Estimates of the Labor Supply Model

<table>
<thead>
<tr>
<th>Preference</th>
<th>Parameter</th>
<th>Married Couples</th>
<th>Single Males</th>
<th>Single Females</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Estimate</td>
<td>S.E.</td>
<td>Estimate</td>
<td>S.E.</td>
</tr>
<tr>
<td>Preferences</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consumption</td>
<td>Exponent</td>
<td>(\alpha_1)</td>
<td>0.664</td>
<td>0.054</td>
</tr>
<tr>
<td>Scale (10^{-4})</td>
<td>(\alpha_2)</td>
<td>1.841</td>
<td>0.352</td>
<td>0.351</td>
</tr>
<tr>
<td>Female leisure</td>
<td>Exponent</td>
<td>(\alpha_3)</td>
<td>(-0.833)</td>
<td>0.182</td>
</tr>
<tr>
<td></td>
<td>Constant</td>
<td>(\alpha_5)</td>
<td>11.84</td>
<td>1.888</td>
</tr>
<tr>
<td></td>
<td>Log(age/10)</td>
<td>(\alpha_6)</td>
<td>(-12.53)</td>
<td>1.945</td>
</tr>
<tr>
<td></td>
<td>Log(age/10) squared</td>
<td>(\alpha_7)</td>
<td>5.246</td>
<td>0.733</td>
</tr>
<tr>
<td></td>
<td>Number of children below age 6</td>
<td>(\alpha_8)</td>
<td>0.968</td>
<td>0.168</td>
</tr>
<tr>
<td></td>
<td>Number of children above age 6</td>
<td>(\alpha_9)</td>
<td>0.508</td>
<td>0.094</td>
</tr>
<tr>
<td>Male leisure</td>
<td>Exponent</td>
<td>(\alpha_4)</td>
<td>(-1.804)</td>
<td>0.430</td>
</tr>
<tr>
<td></td>
<td>Constant</td>
<td>(\alpha_{10})</td>
<td>3.893</td>
<td>1.112</td>
</tr>
<tr>
<td></td>
<td>Log(age/10)</td>
<td>(\alpha_{11})</td>
<td>(-4.305)</td>
<td>1.142</td>
</tr>
<tr>
<td></td>
<td>Log(age/10) squared</td>
<td>(\alpha_{12})</td>
<td>1.668</td>
<td>0.444</td>
</tr>
<tr>
<td></td>
<td>Number of children below age 6</td>
<td>(\alpha_{13})</td>
<td>0.055</td>
<td>0.051</td>
</tr>
<tr>
<td></td>
<td>Number of children above age 6</td>
<td>(\alpha_{14})</td>
<td>0.008</td>
<td>0.029</td>
</tr>
<tr>
<td>Leisure interaction</td>
<td>(\alpha_{15})</td>
<td>0.205</td>
<td>0.147</td>
<td></td>
</tr>
<tr>
<td>The parameters</td>
<td>(\theta_p; \log \theta_p = f_{y_1} + f_{y_2} S)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>(f_{y_1})</td>
<td>(-3.504)</td>
<td>0.435</td>
<td>(-5.301)</td>
</tr>
<tr>
<td>Education</td>
<td>(f_{y_2})</td>
<td>1.239</td>
<td>0.366</td>
<td>2.896</td>
</tr>
<tr>
<td>Opportunity density of offered hours</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male fulltime peak</td>
<td></td>
<td>2.377</td>
<td>0.086</td>
<td>2.558</td>
</tr>
<tr>
<td>Female fulltime peak</td>
<td></td>
<td>1.438</td>
<td>0.296</td>
<td>1.704</td>
</tr>
<tr>
<td>Male part-time peak</td>
<td></td>
<td>1.096</td>
<td>0.063</td>
<td>(-0.177)</td>
</tr>
<tr>
<td>Female part-time peak</td>
<td></td>
<td>0.562</td>
<td>0.067</td>
<td>0.383</td>
</tr>
<tr>
<td>Number of observations</td>
<td></td>
<td>2,511</td>
<td>2,095</td>
<td>1,907</td>
</tr>
<tr>
<td>Log likelihood</td>
<td></td>
<td>(-5,707)</td>
<td>(-1,841)</td>
<td>(-2,273)</td>
</tr>
<tr>
<td>McFadden’s (\rho^2)</td>
<td></td>
<td>0.44</td>
<td>0.55</td>
<td>0.43</td>
</tr>
</tbody>
</table>
### Table A2
Uncompensated Wage Elasticities for Married Couples

<table>
<thead>
<tr>
<th>Elasticity w.r.t. Both Wage Rates</th>
<th>Female</th>
<th>Male</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base Value</td>
<td>Own Wage Elasticity</td>
<td>Cross Wage Elasticity</td>
</tr>
<tr>
<td>Probability of working</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Whole sample</td>
<td>0.89</td>
<td>0.333</td>
</tr>
<tr>
<td>Lowest decile</td>
<td>0.87</td>
<td>0.420</td>
</tr>
<tr>
<td>2nd to 8th decile</td>
<td>0.90</td>
<td>0.332</td>
</tr>
<tr>
<td>Highest decile</td>
<td>0.92</td>
<td>0.249</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mean Hours of work, conditional on working</th>
<th>Female</th>
<th>Male</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Hours of work, conditional on working</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Whole sample</td>
<td>1,601</td>
<td>0.279</td>
</tr>
<tr>
<td>Lowest decile</td>
<td>1,581</td>
<td>0.289</td>
</tr>
<tr>
<td>2nd to 8th decile</td>
<td>1,602</td>
<td>0.279</td>
</tr>
<tr>
<td>Highest decile</td>
<td>1,618</td>
<td>0.272</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Unconditional mean hours of work</th>
<th>Female</th>
<th>Male</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unconditional mean hours of work</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Whole sample</td>
<td>1,444</td>
<td>0.612</td>
</tr>
</tbody>
</table>
change in both wage rates remain practically constant over all income groups. The corresponding unconditional elasticities for females measure the response of total mean hours of work in response to wage changes. In Table A.2 we note that the estimate for the unconditional elasticity for married females is 0.61, somewhat higher than the mean value for females reported in the meta analysis by Evers, de Mooij and van Vuuren (2005), but somewhat smaller than the median estimate in the survey by Blundell and MaCurdy, reported in Heim (2007). However, Table A.3 shows that unmarried females are much less responsive, with an estimate of the (unconditional) wage elasticity of 0.04.

### Table A3

<table>
<thead>
<tr>
<th></th>
<th>Male Base Value</th>
<th>Male Wage Elasticity</th>
<th>Female Base Value</th>
<th>Female Wage Elasticity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Probability of working</td>
<td>0.97</td>
<td>0.023</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean hours of work</td>
<td>1,982</td>
<td>0.03</td>
<td>1,766</td>
<td>0.020</td>
</tr>
<tr>
<td>Conditional on working</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unconditional mean hours</td>
<td>1,720</td>
<td>0.040</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### A3. The LOTTE-Konsum Microsimulation Model of Indirect Taxation

As the LOTTE-Skatt database does not contain consumption data, we employ the LOTTE-Konsum microsimulation model of indirect taxation to obtain estimates of the effects of changes in indirect tax revenues caused by cuts in the personal income tax. The model determines expenditures for 30 different commodities for each household belonging to LOTTE-Skatt, derived from a system of Engel functions with demographic variables, that satisfy the adding-up and non-negativity constraints. This non-linear system, with many corner solutions, is calibrated through an iterative algorithm, such that the sum of expenditures over all households is exactly equal to the aggregate household expenditures for each commodity given by an external source, usually macro model predictions or national account estimates. In the present analysis, which focuses on tax changes for 2006, national accounts information is available and therefore utilized. Note also that derivation of the Engel functions is based on econometric studies of the Norwegian consumer expenditure data (Aasness, Biørn and Skjerpen, 2003).