The Marginal Cost of Public Funds: Hours of Work Versus Labor Force Participation*

Henrik Jacobsen Kleven
University of Copenhagen, EPRU, and CEPR

Claus Thustrup Kreiner
University of Copenhagen, EPRU, and CESifo

Revised: March 2006

Abstract

This paper extends the theory and measurement of the marginal cost of public funds (MCF) to account for labor force participation responses. Our work is motivated by the emerging consensus in the empirical literature that extensive (participation) responses are more important than intensive (hours of work) responses. In the modelling of extensive responses, we argue that it is crucial to account for the presence of non-convexities created by fixed work costs. In a non-convex framework, tax and transfer reforms give rise to discrete participation responses generating first-order effects on government revenue. These revenue effects make the marginal cost of funds higher, and we show numerically that the implications for MCF tend to be substantial. (*JEL* H21, H41, J20)

*We wish to thank Agnar Sandmo, Peter Birch Sørensen, Editor Sören Blomquist, and two anonymous referees for detailed comments on a previous draft, as well as Nada Eissa and Emmanuel Saez for helpful discussions on this topic. The activities of EPRU (Economic Policy Research Unit) are supported by a grant from The Danish National Research Foundation. Corresponding author: Henrik Jacobsen Kleven, Institute of Economics, University of Copenhagen, Studiestræde 6, DK-1455 Copenhagen K, Denmark. E-mail: henrik.kleven@econ.ku.dk, phone: +45 35 32 44 15, fax: +45 35 32 30 00.

1 Introduction

Economists have long been concerned with the optimal level of government spending. The classic formulation of the problem goes back to Samuelson (1954) who analyzed the case where government is financed entirely by lump sum taxation. His analysis was later extended by Stiglitz and Dasgupta (1971) and Atkinson and Stern (1974) to account for the more realistic situation where revenue has to be raised by distortionary taxation. These papers demonstrated that a crucial factor for the optimal size of government is the marginal welfare cost of raising revenue by distortionary taxes, subsequently labelled the marginal cost of public funds (MCF) by Browning (1976).

The contribution by Browning and the literature that followed discussed theoretically how to measure the MCF and tried to estimate its value, typically for the United States. Some papers were based on analytical approaches (Browning, 1987; Mayshar, 1991; Snow and Warren, 1996; Dahlby, 1998) while others were based on computer simulation techniques (Stuart, 1984; Ballard *et al.*, 1985; Ballard, 1990; Ballard and Fullerton, 1992). Considerable effort has been devoted to reconciling disparities in reported estimates arising from different assumptions about the nature of government spending, the type of tax used to finance spending, and labor market behavior.

Despite the differences just mentioned, there are important similarities across the existing studies. First of all, most of the work has focused on the effect of taxation on labor supply, and a lot of attention has been given to the role of the labor supply elasticity for the size of MCF. Secondly, all of the previous studies employed the standard convex model of labor supply, where individual hours of work is determined by the local slope of the budget constraint. In this framework, if the local slope of the budget line changes a little bit, individuals change hours worked a little bit. Hence, there are no discrete changes in labor supply. Thirdly, the literature considers labor supply responses only along the intensive margin, i.e., changes in hours worked for those who are working. Labor supply responses along the extensive margin — the margin of entry and exit — were ignored.

This focus on hours worked for those who are working conflicts with the empirical labor market literature showing that almost all of the observed variation in labor supply is generated by changes in labor force participation (Heckman, 1993; Blundell and MaCurdy, 1999). In fact, participation elasticities seem to be very large for certain subgroups of the population, typically people at the lower end of the earnings distribution. For example, recent expansions to tax-based transfers in the United States created large effects on female labor force participation (Eissa and Liebman, 1996; Meyer and Rosenbaum, 2001). By contrast, hours-of-work elasticities estimated conditional on working tend to be very close to zero across different demographic subgroups and earnings levels.

Saez (2002) has demonstrated that the incorporation of extensive labor supply responses has important implications for the theory of optimal income taxation. In this paper, we explore the implications of extensive labor supply responses for the marginal cost of funds, theoretically as well as empirically. In the modelling of extensive responses, we argue that it is crucial to account for the discreteness of participation behavior. Indeed, empirical distributions of working hours show almost no workers at low annual or weekly hours of work (Eissa *et al.*, 2004). To be consistent with such a distribution, we have to drop the convex model of labor supply, since it implies that marginal increases in the net-of-tax wage induce entry at infinitesimal hours of work. Instead, we set up a model where small tax changes can induce entry at high working hours (say, part-time or full-time work). In the empirical labor market literature, discrete entry is typically explained by fixed work costs creating non-convexities in preferences and in the budget set (e.g. Cogan, 1981). In a model accounting for fixed work costs, we show that extensive responses entail first-order effects on government revenue which unambiguously increase the size of MCF.

We make an empirical contribution by estimating the MCF for a number of European countries. Almost all previous attempts at estimating the MCF were based on a single-agent approach, an exception being the computable general equilibrium (CGE) study by Ballard *et al.* (1985). Because of the large observed heterogeneity in earnings, taxes, transfers and labor supply responses, any attempt to estimate MCF based on a single-agent approach will be prone to substantial errors. In fact, because participation responses are strongly concentrated at the bottom of the distribution, the incorporation of heterogeneity is even more urgent in our case. Our model therefore incorporates heterogeneity in wages, preferences, and in fixed work costs. Based on this model, we derive analytical expressions for the MCF that are functions of observable tax and benefit parameters along with labor supply elasticities on the two margins of response. We then estimate MCF for five European countries using micro data on taxes and benefits from Immervoll *et al.* (2004). In the calculations, we make realistic assumptions about intensive and extensive labor supply elasticities across different income levels based on a review of the empirical literature.

The five countries we consider span a high degree of variation in the size and type of tax and welfare systems. At one end of the spectrum, we have an Anglo-Saxon country (United Kingdom) and a Southern European country (Italy) characterized by small and categorical welfare benefits and relatively low tax burdens on workers. At the other end of the spectrum, we have a Scandinavian system (Denmark) featuring universal and generous low-income support along with very high marginal tax rates. In between these polar cases, we have two Central/Northern Continental European countries (France and Germany) where taxes and transfers also tend to be quite high. The MCF estimates depend crucially on the country under consideration and on the type of tax reform used to collect the additional revenue. In general, we find that extensive responses have very important effects on MCF, especially in countries such as Denmark, Germany, and France where the tax-benefit systems give rise to very high participation tax rates at the bottom of the distribution. For these countries, the estimated MCFs center around 2 in the case of proportional tax changes. On the other hand, for a country such as the UK where the incentive for low-wage individuals to take a job is relatively strong, the impact on MCF from endogenous participation is somewhat smaller than for the other countries.

2 Theoretical Analysis

In the empirical labor supply literature, discrete entry is typically explained by the presence of non-convexities in preferences and/or budget sets created by fixed work costs (Cogan, 1981; Blundell and MaCurdy, 1999). These work costs may be monetary costs (say, expenses to child care and transportation), they may reflect time losses (say, commuting time), or they could be emotional costs arising from the added responsibility and stress associated with having a job. Work costs of this sort tend to create economies of scale in the work decision making very low hours of work unattractive. Below we adopt a framework incorporating fixed costs of working in order to get discrete entry.

We assume that the population may be divided into I distinct subgroups, with N_i denoting the number of individuals in group i. By normalizing the size of the total population at 1,

N_i is also the fraction of individuals in each group. Across different subgroups, we allow for heterogeneity in wage rates as well as in preferences. Within any given group, individuals are characterized by identical wages and preferences, but they are facing heterogeneous fixed costs of work. In particular, we assume a continuum of individuals in each group, with fixed work costs q being distributed according to the cumulative distribution function $P_i(q)$ and the density function $p_i(q)$. By assuming a continuum of fixed costs, the model will generate a smooth participation response at the aggregate level of the group, such that the sensitivity of entry-and-exit behavior may be captured by elasticity parameters for each group.

Individual utility is specified as

$$v_i(c, h) - q \cdot 1(h > 0), \tag{1}$$

where c is consumption, h is hours of work, and $1(\cdot)$ denotes the indicator function. While the subutility function $v_i(\cdot)$ is well-behaved, a non-convexity is introduced through the last component in utility. Conditional on labor market participation ($h > 0$), the individual incurs a fixed utility cost q along with the standard variable disutility of work embodied in the v_i-function. The specification implies that the average work cost per hour is U-shaped — like a standard average total cost curve in production theory — and this tends to make small hours of work unattractive for the individual. If the individual enters the labor market at all, he would do so at some minimum number of working hours, say 20 or 30 hours per week.[1]

For the purpose of simplification, we have assumed separability of fixed costs in the utility function (1). Because of this assumption, the fixed cost will not affect the marginal rate of substitution between leisure and consumption conditional on entry. Hence, while the size of the fixed cost is crucial for the decision to enter the labor market, it will not affect the choice of hours worked once entry has been made. In combination with identical within-group wage rates and preferences, the separability of fixed costs implies that those who are working in a given group do so at the same number of hours. As we shall see below, this formulation allows

[1] Since the non-convexity applies only at the point of entry, the hours-of-work decision conditional on participation will be continuous as in the standard labor supply model. While this makes the analysis simpler, a more general framework incorporating discrete behavior along both the intensive and extensive margins would be tractable. Saez (2002) formulates a discrete occupational choice model to study optimal income taxation, while Kleven and Kreiner (2004) present a discrete labor supply model based on non-convex work cost functions. Under appropriate restrictions on work cost functions, Kleven and Kreiner (2004) derive a formula for the marginal excess burden of taxation resembling the results presented here with a reinterpretation of the intensive labor supply elasticity.

us to capture labor supply responses by setting intensive and extensive elasticities at the level of the group, and it allows us to capture the tax-transfer system by setting marginal tax rates along with virtual incomes for each group rather than each individual.

Taxes and transfers in this model are captured by a function $T(w_i h, z)$, where w_i denotes an exogenous gross wage rate and z is a shift-parameter that we use to capture changes in the tax-transfer system. Besides earnings, the tax-transfer scheme may depend on non-labor income and demographics (kids, marital status, place of residence, etc.), but we surpress this in the notation. While we allow for the T-function to include non-linearities and discontinuities, we restrict attention to the case of piecewise linearity. The budget constraint for individuals in group i is given by $c \leq w_i h - T(w_i h, z)$, which may alternatively be written as

$$c \leq (1 - m_i) w_i h + Y_i, \tag{2}$$

where $m_i \equiv \partial T(w_i h, z) / \partial (w_i h)$ is the marginal tax rate and $Y_i \equiv m_i w_i h - T(w_i h, z)$ is so-called virtual income.

The household maximizes (1) subject to (2). The problem is solved in a two-step procedure: first, we solve for the optimal hours of work conditional on working, and then we consider the choice to participate in the labor market. Conditional on participation ($h > 0$), the optimum is characterized by the standard first-order condition

$$\frac{\partial v_i(c_i, h_i) / \partial h}{\partial v_i(c_i, h_i) / \partial c} = (1 - m_i) w_i, \tag{3}$$

where c_i and h_i denote optimal consumption and hours worked for a participating worker in group i. From (2) and (3), we may write hours worked as a function of the marginal net-of-tax wage rate and the virtual income, i.e. $h_i = h_i((1 - m_i) w_i, Y_i)$. For the individual to enter the labor market in the first place, the utility from participation must be greater than or equal to the utility from non-participation. This implies an upper bound on the fixed cost of working,

$$q \leq v_i(c_i, h_i) - v_i(c_0, 0) \equiv \bar{q}_i, \tag{4}$$

where $c_0 \equiv -T(0, z)$ denotes consumption for non-participants. Individuals with a fixed cost below the threshold-value $\bar{q}_i$ enter the labor market at h_i hours, while those with a fixed cost above the threshold decide not to enter. Since the fixed cost is distributed according to the density function $p_i(q)$, the fraction of individuals in group i who participate in the labor market is given by $\int_0^{\bar{q}_i} p_i(q)\,dq = P_i(\bar{q}_i)$. The aggregate labor supply in group i then equals

$$L_i = N_i \cdot P_i(\bar{q}_i) \cdot h_i((1-m_i)w_i, Y_i). \tag{5}$$

This expression decomposes aggregate labor supply into labor supply along the extensive and intensive margins, and it implies that variation in aggregate labor supply reflects changes along these two margins. This decomposition is central to the analysis in this paper. In particular, we show that the explicit distinction between margins of response is necessary due to the fact that the two margins are related to distinct tax-transfer parameters. While the choice of working hours depends on the marginal tax rate m_i, the participation rate is determined by the threshold-value for the fixed cost $\bar{q}_i$, which is related to total tax liabilities when working and not working, $T(w_i h_i, z)$ and $T(0, z)$.

As measures of the sensitivity along each margin of labor supply, we define an hours-of-work elasticity, ε_i, and a participation elasticity, η_i, with respect to the wage rate:

$$\varepsilon_i \equiv \frac{\partial h_i}{\partial w_i}\frac{w_i}{h_i}, \quad \eta_i \equiv \frac{\partial P_i}{\partial \bar{q}_i}\frac{\partial \bar{q}_i}{\partial w_i}\frac{w_i}{P_i}. \tag{6}$$

With these definitions, we may write the elasticity of aggregate employment L_i with respect to the wage rate — the *total* elasticity — as a sum of the intensive and extensive elasticities, $\varepsilon_i + \eta_i$. Note that ε_i is an uncompensated hours-of-work elasticity. From the Slutsky-equation, it may be decomposed into a compensated elasticity, ε_i^c, and an income effect, θ_i, that is

$$\varepsilon_i = \varepsilon_i^c - \theta_i \gtrless 0, \tag{7}$$

where $\theta_i \equiv -(1-m_i)w_i \cdot \partial h_i/\partial Y_i$ is positive if leisure is a normal good. The hours-of-work elasticity has an indeterminate sign reflecting that the individual labor supply curve may be backward-bending. By contrast, the participation elasticity is always strictly positive.

2.1 The Marginal Cost of Public Funds

In this section and the next, we derive analytical measures of the marginal cost of funds (MCF), defined as the welfare cost from raising one additional dollar of government revenue. A comparison of our results with those in the literature is made complicated by the fact that many different measures of MCF have been proposed. The disparities across the existing measures arise because of different underlying assumptions about, for example, the nature of public spending, the type of tax used to finance spending, and returns to scale in production. A paper by

Snow and Warren (1996) presented an integrated treatment of the theory of MCF, but their framework was limited to the case of a single representative consumer. Our paper is more closely related to Dahlby (1998) who incorporated heterogeneous wage rates into the standard intensive model. By extending Dahlby's analysis to account for non-convexities and endogenous labor force participation, his results can be obtained as special cases of ours by setting extensive elasticities to zero for all individuals.

Before proceeding with the derivations, we should emphasize a modelling choice which is being made. In the utility specification we did not include public goods and, by implication, our results for the MCF will not incorporate any effects of public spending on labor supply and government revenue. While this is the simplest approach, and also the most common one in the recent MCF literature, it would be straightforward to extend our analysis to explicitly incorporate public spending.[2]

The standard approaches to measuring the MCF did not include distributional concerns. But in our framework where individuals are heterogeneous in terms of wages, preferences and fixed work costs, it is natural to start by considering a distributionally-weighted MCF, labelled the social marginal cost of public funds (SMCF). For this purpose, we assume an additive Bergson-Samuelson social welfare function $\Psi(\cdot)$. Aggregate welfare may then be written as

$$W = \sum_{i=1}^{I} \left[\int_{0}^{\bar{q}_i} \Psi_i \left(v_i \left(c_i, h_i \right) - q \right) p_i \left(q \right) dq + \int_{\bar{q}_i}^{\infty} \Psi_i \left(v_i \left(c_0, 0 \right) \right) p_i \left(q \right) dq \right] N_i, \tag{8}$$

where the first term reflects the contribution to welfare from those who are working, while the second term is the contribution to welfare from those outside the labor market. By considering a small change in the tax-transfer system — captured by a change in the z-parameter (dz) — we may define the social marginal cost of public funds in the following way

$$\text{SMCF} = -\frac{1}{\lambda} \frac{dW/dz}{dR/dz}, \tag{9}$$

[2]The approach adopted here has been based on two alternative interpretations. In one interpretation — labelled the Stiglitz-Dasgupta-Atkinson-Stern approach by Ballard and Fullerton (1992) — public goods are simply assumed to be separable in utility so that spending has no effects on labor supply. In the other interpretation, any effects of spending on labor supply and revenue should be ascribed to the benefit side in the cost-benefit analysis used to evaluate a public project. As pointed out by Sandmo (1998), if the goal of MCF is to provide policy makers with a practical measure that can be applied across different public projects, it makes sense not to include the effects of government spending. Because if we did include such effects, each single public project would have to be assigned its own MCF.

where R denotes aggregate government revenue, and where we have defined

$$\lambda \equiv \sum_{i=1}^{I} \left[\int_0^{\infty} \Psi_i' (\cdot) \frac{\partial v_i (\cdot)}{\partial c} p_i (q) \, dq \right] N_i,$$

as the average social marginal utility of income for the entire population. The λ-parameter is of course necessary in the definition in order to convert the welfare effect in utils, dW, into a welfare effect in units of income.

The size of SMCF clearly depends on the characteristics of the tax-transfer change being analyzed. In particular, since our model accounts for non-participation, it is natural to distinguish between, on the one hand, reforms that collect additional revenue by increasing taxes (net of transfers) on the working population and, on the other hand, reforms that increase revenue by lowering transfers (net of taxes) to those outside the labor market. We start by considering an in-work tax reform such that taxes and transfers for the non-employed are kept constant. In the next section, we look at the effects of reforms that affect out-of-work income.

In general, tax reforms affect labor supply along both the intensive and extensive margins. However, these labor supply adjustments have no first-order effects on aggregate welfare in (8), as long as we are considering marginal reforms. This is a result of the envelope theorem applied to each margin of response. Thus, because initial hours of work have been optimized by employed individuals (from eq. 3), small changes in hours worked have no effect on individual welfare v_i and therefore have no effect on aggregate welfare W. Likewise, changes in labor force participation — resulting from a changed threshold value $\bar{q}_i$ — will not affect aggregate welfare because marginal entrants were initially indifferent between working and not working (from eq. 4). The applicability of the envelope theorem to the extensive margin of response results from non-employment being voluntary in this model. We discuss the implications of involuntary unemployment in the concluding remarks, where it is argued that such an extension would not change our main conclusions.

With these insights, it is straightforward to obtain the effect on aggregate welfare as

$$\frac{dW}{dz} = - \sum_{i=1}^{I} \left[\int_0^{\bar{q}_i} \Psi_i' (\cdot) \frac{\partial v_i (\cdot)}{\partial c} \frac{\partial T_i}{\partial z} p_i (q) \, dq \right] N_i, \tag{10}$$

where $\partial T_i / \partial z$ denotes the mechanical increase in the tax payment for a group i individual, i.e., the increase in tax burden excluding any behavioral responses induced by the reform. To simplify this expression, we define social welfare weights on working individuals as

$$g_i(q) \equiv \frac{1}{\lambda}\Psi_i'(v_i(c_i,h_i)-q)\frac{\partial v_i(c_i,h_i)}{\partial c}, \quad g_i \equiv \frac{\int_0^{\bar{q}_i} g_i(q)\,p_i(q)\,dq}{\int_0^{\bar{q}_i} p_i(q)\,dq},$$

where $g_i(q)$ denotes the social marginal utility of income for a working individual in group i with fixed work cost q (relative to the average for the entire population), and where g_i is the average social marginal utility of income among the working population in group i. Using these distributional weights, we may rewrite eq. (10) to

$$\frac{dW/dz}{\lambda} = -\sum_{i=1}^{I} g_i \frac{\partial T_i}{\partial z} P_i(\bar{q}_i)\,N_i, \tag{11}$$

showing that the welfare effect is a weighted sum of the mechanical tax increases for each group.

Besides the welfare effect just derived, the social marginal cost of public funds in (9) depends on the change in government revenue. In fact, it is exactly because of the implications for government revenue that behavioral responses come into play. Aggregate government revenue is given by

$$R = \sum_{i=1}^{I} \left[T(w_i h_i, z)\,P_i(\bar{q}_i) + T(0,z)\,(1-P_i(\bar{q}_i))\right] N_i, \tag{12}$$

where the first term reflects tax payments net of transfers for those who are working, while the second term is tax payments net of transfers (presumably a negative number) for those outside the labor market. The change in aggregate revenue following a reform is then equal to

$$\frac{dR}{dz} = \sum_{i=1}^{I} \left[\frac{\partial T_i}{\partial z} P_i(\bar{q}_i) + m_i w_i \frac{dh_i}{dz} P_i(\bar{q}_i) + (T_i - T_0)\frac{dP_i(\bar{q}_i)}{dz}\right] N_i, \tag{13}$$

where we have used the simplifying notation $T_i \equiv T(w_i h_i, z)$ and $T_0 \equiv T(0,z)$. The mechanical revenue effect from increasing the tax burden on labor income is given by the first term in the expression, while the second and third terms reflect behavioral feed-back effects on revenue from labor supply responses along the intensive and extensive margins. The second term shows the revenue effect created by adjustments in hours worked by those who are working. The size of this revenue effect depends on the magnitudes of the initial marginal tax rates. The third term reflects that some workers will be induced to join the ranks of non-employed people when the tax burden on labor income goes up, creating a revenue effect because of lower tax proceeds and higher aggregate transfer payments to those out of work. The expression shows that the size of this revenue effect depends on the initial tax burden on labor force participation, $T_i - T_0$.

Using eqs (2) to (6), the expression in (13) may be rewritten to

$$\frac{dR}{dz} = \sum_{i=1}^{I} \left[\frac{\partial a_i}{\partial z} - \frac{m_i}{1-m_i} \left(\frac{\partial m_i}{\partial z} \cdot \varepsilon_i^c - \frac{\partial a_i}{\partial z} \cdot \theta_i \right) - \frac{a_i + b_i}{1-m_i} \cdot \frac{\partial a_i}{\partial z} \cdot \eta_i \right] w_i L_i, \tag{14}$$

where $b_i \equiv -T_0/(w_i h_i)$ denotes a benefit rate, $a_i \equiv T_i/(w_i h_i)$ is the average tax rate, and $\frac{\partial a_i}{\partial z} \equiv \frac{\partial T_i}{\partial z}/(w_i h_i)$ is the change in the average tax rate following the reform (excluding behavioral responses). This expression decomposes the intensive revenue effect into a substitution effect being created by the change in the marginal tax rate and an income effect resulting from the change in the average tax rate. We also see that the extensive response is being created by the change in the average tax rate, and that the revenue implications of these responses have to do with the size of $a_i + b_i$, which is the total participation tax rate.

Finally, by inserting eqs (11) and (14) into eq. (9), we obtain our result for the SMCF:

$$\text{SMCF} = \frac{\sum_{i=1}^{I} g_i s_i}{\sum_{i=1}^{I} \left[1 - \frac{m_i}{1-m_i} \left(\Phi_i \varepsilon_i^c - \theta_i \right) - \frac{a_i + b_i}{1-m_i} \eta_i \right] s_i}, \tag{15}$$

where $\Phi_i \equiv \frac{\partial m_i / \partial z}{\partial a_i / \partial z}$ is a measure of the progressivity of the tax change, and where $s_i \equiv \frac{\partial a_i}{\partial z} w_i L_i / \left(\sum_{j=1}^{I} \frac{\partial a_j}{\partial z} w_j L_j \right)$ denotes the tax increase in group i as a share of the total tax increase in the population. The numerator in this expression reflects distributional preferences (equity), whereas the denominator captures behavioral responses (efficiency). The implication of participation responses for SMCF is reflected by the last term in the denominator, while the remaining part of the denominator reflects the 'standard' effect operating through the intensive margin. As demonstrated by other studies, the hours-of-work effect depends on the size of the marginal tax rate, the progressivity of the reform, as well as substitution and income effects on individual labor supply. The size of the participation effect, on the other hand, is related to the average tax rate, the benefit rate, and the participation elasticity. The presence of this new term unambiguously increases the magnitude of SMCF.

From the numerator in (15), SMCF will be relatively large for reforms that concentrate the increased tax burdens on individuals with high social welfare weights. Of course, these distributional weights are subjective and basically unobservable. It is therefore interesting to consider the more standard marginal cost of funds (MCF) measure, which disregards distributional concerns and focus entirely on the efficiency aspect of taxation. This corresponds to assuming that the social value of an extra unit of consumption is uniform across all individuals in society ($g_i = 1 \ \ \forall i$). In this case, we obtain

$$\text{MCF} = \frac{1}{\sum_{i=1}^{I} \left[1 - \frac{m_i}{1-m_i}\left(\Phi_i \varepsilon_i^c - \theta_i\right) - \frac{a_i+b_i}{1-m_i}\eta_i\right] s_i}. \tag{16}$$

This formula demonstrates that, even when we ignore distributional concerns, heterogeneity still matters for the welfare cost of raising government revenue. If the observed heterogeneity in earnings, taxes, benefits, and behavioral parameters is ignored, the estimation of MCF is bound to be erroneous. Indeed, the error could be very large due to the fact that these variables are characterized by a large degree of heterogeneity *and* correlation across the population. This is a serious problem for the numerous studies attempting to quantify the size of MCF based on the representative agent approach. In the numerical section where we estimate MCF, we account for the observed heterogeneity in key parameters.

A relevant question to ask is whether the intensive model used to estimating the MCF (or SMCF) can be saved by a reinterpretation of the labor supply elasticity. In this interpretation, one would introduce extensive responses into the framework simply by using estimates of the *total* labor supply elasticity including both margins of response. In other words, one would be ascribing an estimated participation response to the intensive margin of labor supply in the calculation of MCF. Our results show that such an approach would be prone to errors. First, because extensive and intensive responses affect government revenue in different ways, the two types of response are associated with different tax wedges in MCF. While the intensive effect depends on the marginal tax rate m_i, the extensive effect is related to the participation tax rate $a_i + b_i$. In practice, the participation tax can be substantially different from the marginal tax, especially at the bottom of the income distribution where non-linearities and discontinuities in welfare programs play an important role. A second problem with the suggested interpretation arises because the hours-of-work term is decomposed into an income effect and a substitution effect, weighted by the progressivity parameter Φ_i, and there is no natural way to assign the participation effect to one or the other. To conclude, a precise estimate of the MCF requires an explicit distinction between the two margins of labor supply response.

It is possible to simplify the expression for MCF by making assumptions about the marginal reform. A benchmark case which has received considerable attention in the literature is where the additional revenue is raised through a proportional tax change ($\Phi_i = 1 \ \ \forall i$). Moreover, if we assume that uncompensated hours-of-work elasticities are zero ($\varepsilon_i = 0 \ \ \forall i$) — a case emphasized by Ballard and Fullerton (1992) and others — the standard MCF is exactly equal to 1. This seems to be an interesting result because uncompensated hours-of-work elasticities have in fact been estimated to be close to zero. However, participation elasticities are not close to zero, especially at the bottom of the earnings distribution. When we account for participation effects, MCF is equal to

$$\mathrm{MCF}|_{\substack{\Phi_i=1 \\ \varepsilon_i=0}} = \frac{1}{\sum_{i=1}^{I}\left[1-\frac{a_i+b_i}{1-m_i}\eta_i\right]s_i} > 1,$$

which is always greater than one. In fact, as we shall see in section 3, it is substantially greater than one for European countries when assuming realistic participation elasticities.

Another interesting special case is where the additional revenue is collected by increasing the marginal tax rate in one tax bracket, holding all other marginal tax rates and brackets constant. For the purpose of studying this case, we impose an ordering of subgroups $i = 1, ..., I$ corresponding to the different income brackets in the tax system. Then we consider an increase in the marginal tax rate in bracket k, with all other marginal tax rates being unchanged. In this case, eq. (16) may be rewritten to

$$\mathrm{MCF_k} = \frac{1}{1-\frac{m_k}{1-m_k}\varepsilon_k^c\Phi_k s_k + \sum_{i=k}^{I}\frac{m_i}{1-m_i}\theta_i s_i - \sum_{i=k}^{I}\frac{a_i+b_i}{1-m_i}\eta_i s_i}, \tag{17}$$

where we have used the fact that brackets below k are unaffected by the reform. The reform gives rise to three different effects on labor supply behavior, reflected by the three terms in the denominator. First, because of the higher marginal tax rate in bracket k, workers in this bracket reduce hours worked through a substitution effect. This effect reduces government revenue and increases the size of MCF. Second, all workers with earnings in bracket k or above experience higher tax burdens, which creates an income effect leading to higher hours of work if leisure is a normal good. In isolation, this effect implies a higher revenue and a lower value of MCF. Finally, increased tax burdens will induce some workers to exit the labor market in order to collect benefits, thereby lowering government revenue and increasing MCF.

For discussions on the proper amount and design of income redistribution, it is important to understand the profile of MCF across brackets (k) in the earnings distribution. If $\mathrm{MCF_k}$ is increasing in k, redistribution from rich to poor will be relatively costly, and vice versa. To understand the components determining the profile of $\mathrm{MCF_k}$, notice that each of the three terms in the denominator — the substitution and income effects on hours worked and the participation effect — reflect a behavioral revenue effect in proportion to the mechanical revenue increase. Let us consider each effect in turn. The substitution term will generally be increasing in k, in part because marginal tax rates tend to be increasing, and in part because the term $\Phi_k s_k$ will generally be increasing due to a *productivity effect* and a *tax base effect*. The productivity effect reflects simply that increasing productivities (wages) make reductions in hours of work have larger effects on income and revenue. The tax base effect reflects that, as we increase the bracket level, less individuals will be located above the bracket and it will therefore represent a smaller inframarginal income mass. Hence, as we increase k, the tax increase collects a declining amount of revenue from inframarginal units of income, while it keeps creating negative substitution effects on the margin. Because of all of these effects, the substitution effect tends to make $\mathrm{MCF_k}$ increasing in the bracket level k.

The income effect reflects a weighted average of $\frac{m_i}{1-m_i}\theta_i$ from k to I. The presence of increasing marginal tax rates would tend to make this term increasing. If θ is constant across the distribution, or at least not too sharply declining, the income effect will then be increasing in k. Intuitively, as we raise taxes higher up in the distribution, we are concentrating the positive income effects on hours of work where marginal tax rates are higher and hence where they have the largest effects on revenue and MCF. Hence, the income effects tend to make $\mathrm{MCF_k}$ decreasing in k.

Finally, let us consider the participation effect, captured by the last term in the denominator of (17). This effect reflects a weighted average of $\frac{a_i+b_i}{1-m_i}\eta_i$ from k to I. Empirically, participation elasticities are declining in earnings, which ceteris paribus tend to make $\frac{a_i+b_i}{1-m_i}\eta_i$ declining. On the other hand, the presence of increasing tax rates would tend to modify or reverse this effect. However, the tax rate profile could alternatively reinforce the effect of declining elasticities, because participation tax rates $a_i + b_i$ — as opposed to marginal tax rates — sometimes display a declining profile due to the presence of earnings and work tested benefits at the bottom. All in all, it is likely that the participation term in MCF will be declining, giving rise to a decreasing profile for $\mathrm{MCF_k}$.

In conclusion, the MCF profile is the result of several involved and offsetting effects on the intensive and extensive margins, and the question cannot be settled analytically. In section 3, we explore the issue empirically.

2.2 The Marginal Cost of Funds from a Benefit Reduction

So far, we have focused on the case where additional government revenue is collected by increasing tax burdens on workers. Alternatively, funds can be raised from non-workers by reducing their benefits, corresponding to an increase in the net tax payment T_0. To derive the SMCF from a benefit reduction, we follow the same procedure as in the derivation of (15). This gives

$$\text{SMCF} = \frac{\sum_{i=1}^{I} g_i^u u_i}{\sum_{i=1}^{I} \left[1 + \frac{a_i + b_i}{b_i} \eta_i^u\right] u_i}, \tag{18}$$

where $g_i^u \equiv \Psi' \left(v\left(c_0, 0\right)\right) v_1\left(c_0, 0\right) / \lambda$ is defined as the welfare weight attached to an unemployed individual in group i, $\eta_i^u \equiv \frac{\partial(1-P_i)}{\partial b_i} \frac{b_i}{1-P_i}$ is the elasticity of non-employment with respect to the benefit rate, and $u_i \equiv \frac{N_i(1-P_i(\bar{q}_i))}{\sum_{i=1}^{I} N_i(1-P_i(\bar{q}_i))}$ is group i's share of total unemployment. The expression reflects the trade-off between equity (numerator) and efficiency (denominator) for transfer reforms. Typically, the non-employed population will be characterized by a high concentration of low-ability individuals, and the non-employed tend to face relatively high work costs. It is therefore natural to assume that the average welfare weight on the non-employed population (the numerator in 18) is relatively large. In isolation, this makes the SMCF for out-of-work benefit reform higher than the SMCF for tax reform on workers considered in the previous section. On the other hand, a reduction in benefits creates an efficiency gain resulting from higher labor force participation. To isolate this gain, we abstract from distributional concerns ($g_i^u = 1 \;\; \forall i$) so as to obtain the MCF for benefit reform

$$\text{MCF} = \frac{1}{\sum_{i=1}^{I} \left[1 + \frac{a_i + b_i}{b_i} \eta_i^u\right] u_i} \leq 1. \tag{19}$$

This expression shows that it costs less than a dollar to collect an additional dollar in government revenue by lowering out-of-work transfers. Reduced transfer payments increase work incentives inducing some individual to move from being net beneficiaries to being net contributors to the tax-benefit system. To get an idea of the possible magnitude of this behavioral effect on government revenue and MCF, it is interesting to evaluate the above expression for an unemployment-benefit elasticity equal to 1, a realistic value according to the survey by Krueger and Meyer (2002). In this case, the above expression shows that it will always cost less than 50 cents to raise revenue by a dollar, independent of the other parameters.

3 Numerical Analysis

3.1 Tax-Benefit Data and Elasticity Scenarios

This section reports estimates of the marginal cost of funds, accounting for labor supply responses at both the intensive and extensive margins. We consider five European countries — Denmark, France, Germany, Italy, and the UK — which have been chosen to span a high degree of variation in the size and type of tax and welfare systems.[3] Our MCF calculations are based on the formulas in section 2 along with information on earnings, marginal tax rates, participation tax rates and labor supply elasticities. We obtain microdata on earnings and effective tax rates from Immervoll *et al.* (2005), which provided a careful study of taxes and benefits across the 15 pre-expansion EU countries using the EUROMOD microsimulation model. Table I presents this data based on an aggregation into 10 earnings deciles. We let these 10 deciles constitute the I subgroups in the analytical expressions.

The elasticity scenarios which we consider — shown in Table II — is based on the review of the empirical labor supply literature in Kleven and Kreiner (2006). Four scenarios are within the standard convex framework with only intensive responses. We wish to consider this model to create a benchmark against which we can compare the results from the more realistic model with participation responses. Moreover, it is interesting to compare our results from the intensive model to the existing MCF estimates, because we account for the observed heterogeneity in earnings, taxes and benefits across income deciles, based on homogeneous microdata for a number of different countries. Almost all existing estimates were based on the representative agent model and focused on the United States (e.g., Browning, 1987; Ballard and Fullerton, 1992). As shown in the table, we consider two scenarios (S1 and S2) with an average intensive elasticity equal to zero, and two scenarios (S3 and S4) with an average elasticity at 0.1. While scenarios S1 and S3 assume a constant elasticity across deciles, scenarios S2 and S4 involve a gradually falling hours-of-work elasticity. The latter scenarios are consistent with evidence suggesting a backward-bending labor supply curve (Blundell, 1996), featuring elasticities that are declining in earnings and become negative at high earnings-levels.

The next five scenarios (S5-S9) are based on the Intensive-Extensive model developed in section 2. For the intensive elasticity, these scenarios assume that it is constant across deciles

[3] A longer version of the paper (Kleven and Kreiner, 2006) shows estimates of MCF for all 15 member countries of the European Union prior to the 2004-expansion.

and small (0 or 0.1). For the extensive elasticity, on the other hand, the available evidence suggests that it is substantially larger, perhaps above 0.5, for the groups in the lower part of the income distribution. Participation elasticities in the middle part of the distribution are likely to be substantially lower, while there is almost no responsiveness of labor force participation at the top of the distribution. Hence, all of the scenarios feature declining participation elasticities across deciles, with elasticities between 0.3 and 0.8 at the bottom of the distribution and zero elasticities at the top. The scenarios differ with respect to the degree of concentration of participation responses at the bottom and with respect to the average level of the participation elasticity for the whole economy (0.1, 0.2, and 0.3, respectively).

3.2 Quantifying the Marginal Cost of Funds

Based on the effective tax rates and wage shares shown in Table I, along with the elasticity scenarios presented in Table II, we are able to compute estimates of MCF for Denmark, France, Germany, Italy and the UK. We start by considering proportional tax reform, which is the case most often considered in the MCF literature. The results are shown in Table III for the standard intensive model (S1-S4) as well as the intensive-extensive model (S5-S9).

In the first scenario where intensive and extensive elasticities are zero in all deciles, MCF is equal to 1 for all countries. As pointed out by Ballard and Fullerton (1992) and others, this will always be the case for proportional tax changes assuming a zero uncompensated hours-of-work elasticity. However, the previous papers made this point based on the single-agent model, which depends simply on a total labor supply elasticity for the economy. In our framework, which allows for heterogeneity in labor supply responses across individuals, the result requires that intensive elasticities are zero for each single individual (or each subgroup) in the population. Clearly, even if the intensive elasticity is zero in the aggregate, this need not be the case for each income group. Hence, the second scenario considers an intensive elasticity which is declining in income, keeping the average at zero, consistent with evidence suggesting a backward-bending labor supply curve. In this case, MCF is below 1 for each country. This result reflects a correlation between responses, productivities, and marginal tax rates. Raising marginal tax rates reduces labor supply mostly at the bottom of the distribution where the responses are less important for efficiency due to low productivities and low marginal tax rates. By contrast, due to the backward-bending labor supply curve, higher taxes lead to higher working hours at the top of the distribution. Since these positive responses take place at high wage levels and at high marginal tax rates, they generate gains that dominate the losses at the lower end of the distribution, implying an MCF below 1.

In the next two scenarios, we consider an average intensive elasticity at 0.1, which may be either constant (S3) or declining (S4). A comparison of MCF estimates for the two scenarios confirms once more that heterogeneity in labor supply responses is very important for the welfare cost of taxation. Interestingly, in the fourth scenario, MCF is close to 1 for all countries even though the hours-of-work elasticity is positive on average and probably at a realistic level. In fact, the MCF numbers in this scenario are lower than most existing estimates, even though they were typically based on the United States where taxes and transfers are relatively low. The low numbers in scenario 4 reflect in part the correlation between elasticities, productivities and tax rates described above. Yet, even for constant intensive elasticities across deciles, the MCF levels reported in the table are modest, varying from 1.10 for UK to 1.29 for Denmark. To summarize, under realistic intensive elasticities and proportional reform, the convex labor supply model generates quite low costs of financing public goods.

Scenarios 5 through 9 incorporate participation responses in the MCF computations, demonstrating just how important this effect is for the results. In scenario 5, based on intensive elasticities equal to zero and extensive elasticities equal to 0.2 on average and with a declining profile, the size of MCF varies from 1.13 for the United Kingdom to 1.47 for Denmark. To compare, the standard convex labor supply model would yield an MCF equal to 1 for all countries in this case. Alternatively, if the intensive elasticities are set to 0.1 in all deciles while the extensive elasticities are kept unchanged (S6) — perhaps a natural baseline scenario — the size of MCF varies from 1.26 for the UK to 2.20 for Denmark. In between these two countries, we have Italy at 1.52, France at 1.72, and Germany at 1.85. Comparing these estimates to those in scenario 3, we see that the isolated impact of participation responses on MCF can be very large. Notice also that the effect of accounting for extensive responses is larger when the intensive elasticities are positive (S6 vs S3) than when they are zero (S5 vs S1) due to the non-linearity of the marginal cost of funds. If the intensive margin is more distorted (because of higher elasticities), the consequences of adding the extensive margin will be more severe.

Scenarios 7-9 explore the sensitivity of MCF to the profile and the level of the participation elasticity. A stronger concentration of participation responses at the bottom of the distribution

(S7) implies a lower MCF for all countries. As discussed above, the size of MCF depends on the correlation between elasticities, productivities, and tax rates. When responses are occurring at lower producticity levels and at lower tax rate levels, they are less important for government revenue and efficiency. For the extensive margin, the effect of concentrating responses at the bottom is not unambiguous in all countries, because participation tax rates may be higher at the bottom than at the top due to earnings and work tested benefits (e.g. in Denmark). Nonetheless, the effect of lower productivities at the bottom is sufficient to imply a lower MCF for all countries in scenario 7. The last two scenarios show the effect of lowering or increasing participation elasticities (S8 and S9). Not surprisingly, the size of MCF is quite sensitive to the magnitude of participation responses. The sensitivity of MCF is a lot larger in countries where the initial equilibrium is more distorted from the tax-transfer system (Germany, France, and Denmark) than in countries with lower initial distortions (UK and Italy).

While the case of proportional tax change constitutes an important benchmark, our analytical framework and data allow us to consider any type of nonlinear reform. An interesting class of nonlinear reforms, discussed in the theoretical section, change the marginal tax rate in just one income bracket, while keeping constant the marginal tax rate in all other brackets. We discussed analytically how MCF might vary as we move the income bracket where the tax change is occurring, an issue we would like to explore empirically. Hence, Table IV shows the value of MCF associated with an isolated increase in the marginal tax rate in each of the 10 income deciles for the five countries. The upper panel shows results from the standard intensive model, while the lower panel shows results from the intensive-extensive model. Since we are considering a nonlinear reform, it becomes necessary to set both uncompensated and compensated hours-of-work elasticities. Both panels assume an uncompensated elasticity equal to 0.1 across all deciles and a compensated elasticity equal to 0.2 across all deciles, implying a uniform income effect θ equal to 0.1. The participation elasticities in the lower panel correspond to our previous benchmark case (S6).

In the upper panel, we see that the standard model implies sharply increasing MCFs across the earnings distribution, with values below 1 at the bottom of the distribution and very high values or Laffer effects ('L') at the top of the distribution. This increasing profile reflects that the substitution effect on hours worked becomes increasingly important in the MCF calculation due to the productivity and tax base effects discussed in section 2.1. Once we account for participation responses in the lower panel, the profile for MCF becomes flatter, because these responses occur most strongly at the bottom of the distribution. Nonetheless, MCF retains its increasing profile under the elasticity scenario considered in the table. In scenarios with participation responses being more strongly concentrated at the bottom of the distribution, it is possible to obtain a U-shape for the MCF, with its value being highest at the tails and somewhat lower in the middle.

4 Discussion

This paper explored the implications of extensive labor supply responses for the theory and measurement of the marginal cost of public funds. In the modelling of extensive responses, we argued that it is crucial to account for the presence of non-convexities created by fixed work costs. In the non-convex framework, tax and transfer reforms give rise to discrete participation responses generating first-order effects on government revenue. These revenue effects make the marginal cost of funds higher, and we showed empirically that the implications for the size of MCF are substantial. In general, the quantitative effects depend on the size of participation elasticities and participation tax rates. Because participation responses tend to be concentrated at the bottom of the earnings distribution, they are more important in countries characterized by large earnings and work tested benefits creating high participation tax rates at the bottom.

Our analysis abstracted from a number of issues which we would like to discuss briefly. First, we did not model the decisions to work in the underground sector, although observed labor supply responses — participation and hours worked in the formal labor market — may be closely linked with illegal work in the informal labor market. However, although underground activities were not explicitly modelled, they are implicitly accounted for in the MCF calculations. To see this, recall that the size of MCF reflects behavioral *revenue* effects. In other words, behavioral responses matter only to the extent that they affect government revenue, an implication of the assumptions of rational individuals and efficient markets (e.g. Kleven and Kreiner, 2005). Since an increased amount of work in the untaxed underground economy does not generate revenue, it does not affect MCF. Of course, the presence of an informal sector is likely to influence the degree to which higher taxes reduce labor supply in the formal labor market, but this is incorporated in the labor supply elasticities.

Second, it was assumed that labor markets are perfectly competitive and that unemployment is voluntary. While this assumption may be a good approximation for Anglo-Saxon countries, it is more controversial as a description of Continental European and Scandinavian labor markets. In these countries, minimum wages are high and wage rates tend to be the result of bargaining between unions and firms. Minimum wages prevent employers from paying wages below a defined minimum, eliminating low-productivity jobs and creating involuntary unemployment among the low-skilled. Likewise, imperfections created by union bargaining give rise to involuntary unemployment, as will the presence of search frictions and efficiency wages.

The effects of taxation in imperfect labor markets have been explored in a number of papers. The introduction of imperfections would not change the main mechanisms in our analysis. In imperfect labor markets, variation in employment continues to be the result of behavioral responses along the intensive and extensive margins. For example, Sørensen (1999) considers optimal tax progressivity in three different models of involuntary employment (unions, efficiency wages, and search) where both hours-of-work and participation effects are present. More recently, Boone and Bovenberg (2004) considered optimal nonlinear income taxation in a search model allowing for responses along both the intensive and extensive margins. Consistent with the framework in our paper, theories of imperfect labor markets predict that a higher average tax rate leads to higher unemployment, but with the effect being transmitted through the equilibrium wage rate instead of individuals' voluntary participation decisions. This effect on unemployment affects government revenue and MCF in the same way as it does in the perfect labor market model. However, there would be an additional welfare effect in the imperfect labor market model. Following a small tax increase, those who are fired from their jobs experience discrete (rather than infinitesimal) utility losses, resulting from their job losses being involuntary. This effect clearly increases the size of MCF, reinforcing our theoretical and numerical conclusions on the consequences of extensive responses for MCF. Indeed, a recent working paper by Dahlby (2005) considers the marginal cost of funds in the simple Shapiro-Stiglitz efficiency wage model, confirming that these discrete individual utility losses created by higher unemployment tend to make the extensive margin even more important for MCF.

Third, our derivation of MCF was based on a partial equilibrium framework with exogenous wage rates. The results would carry over to a general equilibrium setting under the assumptions of constant returns to labor and perfect substitution between the different labor types. Under these assumptions, the marginal productivity of each individual would be constant ensuring fixed wage rates in equilibrium. A more realistic model would allow for imperfect substitutability between the different types of labor. Depending on the elasticities of substitution between labor types — something we lack strong empirical knowledge about — this extension would involve ambiguous effects on MCF.

It seems natural to replace the assumption of constant returns to labor with an assumption of constant returns to labor and capital. Assuming a fixed capital stock, this implies decreasing returns to labor which can be shown to reduce MCF (Mayshar, 1991). The reason is that a tax reform reducing labor supply leads to higher gross wages which, ceteris paribus, increase earnings and tax revenue. However, the assumption of a fixed capital stock is only appropriate in the short run. A change in the input of labor affects the return to capital, thereby changing capital accumulation and future welfare. An analysis of a permanent tax reform should account for these long run effects when computing MCF. Indeed, our model may be interpreted as an analysis focusing entirely on the long run impact of tax reforms. To see this, think of a steady state in a standard Ramsey-type model with intertemporal savings decisions by households and a production technology exhibiting constant returns to labor and capital. In this model, the steady state capital-labor ratio is determined entirely by the rate of time preference implying that output per unit of labor is fixed. Thus, in the steady state, output is linear in labor as in our static model. The size of MCF is still given by the behavioral responses on government revenue, and the MCF derived in our static model measures therefore the steady-state change in welfare costs following a (marginal) increase in taxation in the more complicated dynamic general equilibrium model. The steady state comparison does not account for the welfare change along the dynamic path between the two steady states. Such an analysis requires a fully intertemporal model and would become very cumbersome.[4]

References

Atkinson, A.B. and N.H. Stern (1974). "Pigou, Taxation and Public Goods." *Review of Economic Studies* 41, 119-128.

Ballard, C.L. (1990). "Marginal Welfare Cost Calculations : Differential Analysis vs. Balanced-

[4] Judd (1987) provided a fully dynamic general equilibrium analysis of the welfare cost of labor taxation in a model focusing on intensive labor supply responses of a representative individual under proportional taxation.

Budget Analysis." *Journal of Public Economics* 41, 263-276.

Ballard, C.L. and D. Fullerton (1992). "Distortionary Taxes and the Provision of Public Goods." *Journal of Economic Perspectives* 6, 117-131.

Ballard, C.L., J.B. Shoven, and J. Whalley (1985). "General Equilibrium Computations of the Marginal Welfare Costs of Taxes in the United States." *American Economic Review* 75, 128-138.

Blundell, R.W. (1996). "Labour Supply and Taxation," in M. P. Devereux (ed.), *The Economics of Tax Policy*, Oxford University Press, Oxford.

Blundell, R.W. and T. MaCurdy (1999). "Labor Supply: A Review of Alternative Approaches," in O. Ashenfelter and D. Card (eds.), *Handbook of Labor Economics* 3A. Amsterdam: North-Holland.

Boone, J. and L. Bovenberg (2004). "The optimal taxation of unskilled labour with job search and social assistance." *Journal of Public Economics* 88, pp. 2227-2258.

Browning, E.K. (1976). "The Marginal Cost of Public Funds." *Journal of Political Economy* 84, 283-298.

Browning, E.K. (1987). "On the Marginal Welfare Cost of Taxation." *American Economic Review* 77, 11-23.

Cogan, J.F. (1981). "Fixed Costs and Labor Supply." *Econometrica* 49, 945-963.

Dahlby, B. (1998). "Progressive Taxation and the Social Marginal Cost of Public Funds." *Journal of Public Economics* 67, 105-122.

Dahlby, B. (2005). "The Marginal Cost of Public Funds with Involuntary Unemployment." Department of Economics, University of Alberta Working Paper Series 2005-13.

Eissa, N., H.J. Kleven, and C.T. Kreiner (2004). "Evaluation of Four Tax Reforms in the United States: Labor Supply and Welfare Effects for Single Mothers" NBER Working Paper no. w10935.

Eissa, N. and J. Liebman (1996). "Labor Supply Response to the Earned Income Tax Credit." *Quarterly Journal of Economics* 61, 605-37.

Heckman, J.J. (1993). "What Has Been Learned About Labor Supply in the Past Twenty Years?" *American Economic Review Papers and Proceedings* 83, 116-121.

Immervoll, H., H.J. Kleven, C.T. Kreiner, and E. Saez (2005). "Welfare Reform in European Countries: A Micro-Simulation Analysis." Revised version of CEPR Discussion Paper

4324. *Economic Journal* (forthcoming).

Judd, K.L. (1987). "The Welfare Cost of Factor taxation in a Perfect-Foresight Model." *Journal of Political Economy* 95, 675-709.

Kleven, H.J. and C.T. Kreiner (2004). "A Note on the Welfare Evaluation of Tax Reform with Non-Convex Preferences and Discrete Labor Supply." Department of Economics, University of Copenhagen, Working Paper.

Kleven, H.J. and C.T. Kreiner (2005). "Labor Supply Behavior and the Design of Tax and Transfer Policy." *Danish Journal of Economics* 143, 321-358.

Kleven, H.J. and C.T. Kreiner (2006). "The Marginal Cost of Public Funds: Hours of Work Versus Labor Force Participation." CEPR Discussion Paper (forthcoming).

Krueger, A.B. and B.D. Meyer (2002). "Labor Supply Effects of Social Insurance," in Auerbach and Feldstein (eds.), *Handbook of Public Economics* 4. Amsterdam: North-Holland.

Mayshar, J. (1991). "On Measuring the Marginal Cost of Funds Analytically." *American Economic Review* 81, 1329-1335.

Meyer, B. and D. Rosenbaum (2001). "Welfare, the Earned Income Tax Credit, and the Labor Supply of Single Mothers." *Quarterly Journal of Economics* 66, 1063-1114.

Saez, E. (2002). "Optimal Income Transfer Programs: Intensive Versus Extensive Labor Supply Responses." *Quarterly Journal of Economics* 117(3), 1039-1073.

Samuelson, P.A. (1954). "The Pure Theory of Public Expenditure." *The Review of Economics and Statistics* 36, 387-389.

Sandmo, A. (1998). "Redistribution and the marginal cost of public funds." *Journal of Public Economics* 70, 365-382.

Snow, A. and R.S. Warren Jr. (1996). "The Marginal Welfare Cost of Public Funds: Theory and Estimates." *Journal of Public Economics* 61, 289-305.

Stiglitz, J.E. and P. Dasgupta (1971). "Differential Taxation, Public Goods and Economic Efficiency." *Review of Economic Studies* 38, 151-174.

Stuart, C. (1984). "Welfare Costs per Dollar of Additional Tax Revenue in United States." *American Economic Review* 74, 352-362.

Sørensen, P.B. (1999). "Optimal Tax Progressivity in Imperfect Labor Markets." *Labour Economics* 6, pp. 435-452.

Table I: Wage shares and tax rates across earnings deciles

Decile:	1	2	3	4	5	6	7	8	9	10	Average
					Wage shares (s_i)						
Denmark	0.04	0.06	0.07	0.08	0.09	0.09	0.10	0.12	0.14	0.22	0.10
France	0.03	0.05	0.06	0.07	0.08	0.09	0.10	0.12	0.15	0.26	0.10
Germany	0.02	0.05	0.07	0.08	0.09	0.10	0.11	0.13	0.15	0.22	0.10
Italy	0.03	0.06	0.07	0.08	0.08	0.09	0.10	0.12	0.14	0.23	0.10
UK	0.02	0.04	0.05	0.07	0.08	0.09	0.11	0.13	0.16	0.25	0.10
					Marginal tax rates (m_i)						
Denmark	0.65	0.65	0.65	0.66	0.65	0.65	0.69	0.71	0.73	0.73	0.68
France	0.53	0.73	0.65	0.59	0.59	0.61	0.60	0.61	0.63	0.67	0.62
Germany	0.64	0.66	0.68	0.67	0.68	0.67	0.68	0.68	0.65	0.57	0.66
Italy	0.52	0.57	0.60	0.58	0.61	0.60	0.64	0.64	0.62	0.64	0.60
UK	0.39	0.48	0.50	0.53	0.48	0.47	0.46	0.46	0.42	0.51	0.47
					Participation tax rates ($a_i + b_i$)						
Denmark	0.84	0.80	0.77	0.78	0.74	0.73	0.73	0.72	0.70	0.71	0.75
France	0.68	0.72	0.73	0.73	0.71	0.71	0.71	0.70	0.70	0.71	0.71
Germany	0.53	0.65	0.69	0.71	0.71	0.71	0.70	0.71	0.71	0.67	0.68
Italy	0.52	0.53	0.53	0.54	0.54	0.54	0.55	0.56	0.56	0.57	0.54
UK	0.39	0.44	0.50	0.51	0.52	0.50	0.52	0.51	0.50	0.49	0.49

Note: The data is constructed using the EU micro simulation model EUROMOD. The earnings deciles are based on individual earnings of those aged 18 to 59 who have been working the full year. The tax rates include income taxes, social security contributions and consumption taxes. The tax rates also account for the claw-back of benefits (social assistance, unemployment insurance benefits, housing benefits, child benefits etc.) when earnings are increased. For further details see Immervoll et al. (2004).

Table II: Labor supply elasticities across earnings deciles for different elasticity scenarios

Decile:		1	2	3	4	5	6	7	8	9	10	Average
						Elasticity scenarios, standard model						
S1	ε :	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
S2	ε :	0.2	0.2	0.1	0.1	0.0	0.0	-0.1	-0.1	-0.2	-0.2	0.0
S3	ε :	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
S4	ε :	0.3	0.3	0.2	0.2	0.1	0.1	0.0	0.0	-0.1	-0.1	0.1
						Elasticity scenarios, intensive-extensive model						
S5	ε :	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	η :	0.4	0.4	0.3	0.3	0.2	0.2	0.1	0.1	0.0	0.0	0.2
S6	ε :	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	η :	0.4	0.4	0.3	0.3	0.2	0.2	0.1	0.1	0.0	0.0	0.2
S7	ε :	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	η :	0.8	0.6	0.4	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.2
S8	ε :	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	η :	0.4	0.3	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1
S9	ε :	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	η :	0.6	0.6	0.4	0.4	0.3	0.3	0.2	0.2	0.0	0.0	0.3

Note: ε is uncompensated the hours-of-work elasticity and η is the participation elasticity.

Table III: The marginal cost of public funds for proportional tax changes, under different elasticity scenarios

Elasticity scenario	S1	S2	S3	S4	S5	S6	S7	S8	S9
Denmark	1.00	0.85	1.29	1.05	1.47	2.20	1.90	1.54	3.51
France	1.00	0.88	1.21	1.04	1.32	1.72	1.57	1.37	2.20
Germany	1.00	0.90	1.23	1.08	1.38	1.85	1.55	1.37	2.55
Italy	1.00	0.89	1.19	1.04	1.22	1.52	1.40	1.29	1.79
UK	1.00	0.93	1.10	1.02	1.13	1.26	1.18	1.14	1.36

Note: The numbers are computed by inserting wage shares, tax rates and labor supply elasticities from Table 1 and Table 2 into eq. (16).

Table IV: The marginal cost of public funds for an increase in the marginal tax rate in bracket k

	Bracket/decile where the marginal tax is increased (k)									
Country	1	2	3	4	5	6	7	8	9	10
					Standard Model					
Denmark	0.84	0.96	1.19	2.08	2.24	4.00	L	L	L	L
France	0.86	1.05	1.19	1.36	1.51	1.69	1.98	1.99	2.36	14.69
Germany	0.85	0.93	1.04	1.32	2.27	2.52	8.98	14.82	L	14.94
Italy	0.88	0.94	1.14	1.39	1.87	2.09	2.69	4.15	4.77	L
UK	0.92	0.95	1.00	1.09	1.14	1.21	1.28	1.47	1.52	2.68
					Intensive-Extensive Model					
Denmark	1.34	1.51	1.92	4.50	4.10	9.91	L	L	L	L
France	1.29	1.59	1.71	1.89	2.01	2.12	2.34	2.14	2.36	14.69
Germany	1.26	1.37	1.51	1.98	4.13	3.97	59.07	37.30	L	14.94
Italy	1.13	1.19	1.46	1.80	2.48	2.62	3.27	4.65	4.77	L
UK	1.10	1.13	1.17	1.24	1.26	1.31	1.34	1.51	1.52	2.68

Note: The numbers are computed from eq. (17) using wage shares, tax rates and labor supply elasticities displayed in Table 1 and Table 2. We use elasticity scenario S3 for the standard model and scenario S6 for the intensive-extensive model. In these two scenarios, the uncompensated hours-of-work elasticity equals 0.1. The calculations also depend on the compensated hours-of-work elasticity which is set equal to 0.2. An "L" indicates that the tax rate is above the Laffer curve maximum.