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Abstract:

The marginal cost of public funds (MCF) is substantial in generous welfare state countries according to Kleven and Kreiner (2006). Their main estimate for the Danish economy exceeds 2 mainly because taxation distorts labor force participation. Adjustments in social transfers which alleviate such extensive margin distortions are however not considered. This study shows that MCF within a similar welfare state country, Norway, should be in the interval 1.06- 1.16 when social transfers alleviate such distortions.

Keywords: Marginal cost of public funds, Optimal income taxation, Social security transfers, tagging

JEL classification: H21; H23; H41

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Sammendrag

Mange offentlige prosjekter finansieres med skatter som har negative virkninger på økonomien. Kostnadene av slike negative virkninger implementeres i nytte-kostnadsanalyser ved at kostnadene multipliseres med en faktor, MCF. Norge har benyttet en MCF lik 1.2 de senere årene.

Skatter påvirker arbeidstilbudet negativt ved at både arbeidstiden og arbeidsdeltakelsen reduseres. Kleven og Kreiner (2006) viser at negative virkninger på deltakelsen i arbeidslivet fører til vesentlig høyere anslag på MCF. Anslagene for den Danske økonomien øker fra 1.29 til 2.20 i deres basis scenario. Min analyse viser imidlertid at MCF bør ligge i intervallet 1.04-1.10 for USA, og 1.06-1.16 for Norge. Analysen viser også at negative virkinger av beskatning på deltakelse i arbeidslivet har en marginal effekt på MCF.

Negative virkninger av beskatning på deltakelse i arbeidslivet er ifølge Kleven og Kreiner (2006) betydelige pga. en stor skattekile, som består av inntektsskatt og tap av sosiale overføringer, samt en vesentlig reduksjon i deltakelsen som følge av økt beskatning. De analyserer imidlertid ikke scenarioer der økt inntektsskatt kombineres med reduserte sosiale overføringer, eller økte overføringer til trygdemottakere som jobber. Slike endringer i overføringene ville motvirke den negative effekten på deltakelse. De studerer dessuten et sub-optimalt skattesystem der kostnadene ved å øke skatten er høyere enn gevinsten av sosiale overføringer. Dette vil påvirke beregninger av MCF ifølge Jacobs (2018).

Min studie analyserer hvordan MCF påvirkes av deltakelse i arbeidslivet når skatter og sosiale overføringer tilpasses slik at velferden maksimeres. Studien finner som nevnt at MCF i Norge bør ligge i intervallet 1.06-1.16, og at negative effekter på deltakelse har en marginal effekt på anslaget på MCF. Forklaringen er at velferdsgevinsten per kroner investert i kollektive goder må matche velferdsgevinsten av å bruke kroner på sosiale overføringer. Målrettede sosiale overføringer til grupper med høyere nytte av inntekt øker avkastningskravet til offentlige prosjekter. Dermed økes MCF. Gevinsten av slike overføringer reduseres imidlertid om overføringen fører til lavere deltakelse i arbeidslivet. Negative effekter av lavere deltakelse motvirkes imidlertid ved å tilpasse systemet for overføringer. Dette forklarer hvorfor effekter av deltakelse på MCF er marginal. Forenklede forutsetninger innebærer at de numeriske resultatene bør tolkes som illustrasjoner.

Tidligere studier benytter forskjellige definisjoner på MCF. Min studie bidrar ved å beregne en MCF-faktor som implementerer det velferdsmaksimerende tilbudet av kollektive goder. En sammenlikning med denne faktoren og den mest brukte definisjonen av MCF, viser at begge målene gir om lag like anslag på MCF.

1. Introduction

Most public projects are financed with tax revenue from distorting taxes. The cost of such distortions is incorporated into cost-benefit analyses of public projects by multiplying costs with a factor, MCF, or the Marginal Cost of public Funds. Labor supply is distorted as taxation affects both hours of work (intensive margin) and labor force participation (extensive margin). Kleven and Kreiner (2006) show that incorporation of extensive margin choices leads to a substantial increase in estimates of MCF, especially for large welfare state countries. Estimates for the Danish economy increase from 1.29 to 2.20 within their basic scenario. The present study, however, estimate that MCF for a similar large welfare state country, Norway, should be in the interval 1.06- 1.16. Furthermore, the sudy shows that labor force participations choices have a marginal impact on MCF estimates when taxation is combined with social transfers designed to maximize welfare.

The cost of raising tax revenue in the presence of extensive margin distortions is substantial for two reasons according to Kleven and Kreiner (2006). First, the effective tax rate which distorts labor force participation choices consists of both income taxation and loss of transfers. This effective tax rate is substantial in many countries according to Immervoll et al. (2007) and OECD (2009). Second, the empirical literature shows that variation in the supply of labor is mostly generated by changes in labor force participation by people at the lower end of the earnings distribution, see Heckman (1993), Blundell and MaCurdy (1999), Eissa and Liebman (1996) and Meyer and Rosenbaum (2001). Indeed, a substantial share of intended recipients of welfare programs choose to work, see Moffitt (2003) and Currie (2006).

Kleven and Kreiner (2006), however, do not consider reforms where income taxation is combined with reductions in social transfers to non-workers, or transfers to social welfare recipients that decide to work. Such adjustments in social transfers are likely to boost labor force participation, see Kostøl and Mongstad (2014), and hence, alleviate extensive margin distortions. Indeed, optimal tax systems should stimulate labor force participation by offering tax credits similar to the Earned Income Tax Credit implemented in the US, see Saez (2002) and Immervoll et al. (2007). Also, Kleven and Kreiner (2006) assume a sub- optimal tax system where the welfare cost of raising tax revenue exceeds the welfare gain of transfers to non-workers. Jacobs (2018) however shows that this assumption is crucial as a Diamond- based definition of MCF exceeds (equals) one when the welfare cost of raising tax revenue exceeds (equals) the welfare gain of transfers.

Several studies on optimal taxation show cases where redistribution imply that MCF equals one, or where the Samuelson rule holds, see e.g. Hylland and Zeckhauser (1979), Boadway and Keen (1993), Kaplow (1996), Sandmo (1998), Christiansen (1981), Christiansen (2007) and Jacobs (2018). These studies assume that the government redistributes income by giving uniform transfers to all individuals. Uniform transfers and quasilinear preferences implies that the value of transfers, i.e. the value of money in the public sector, equals the average marginal utility of money in the private sector. Hence, MCF defined as the marginal value of money in the public sector divided by the average marginal value of money in the private sector equals one in this case, see Jacobs (2018). Sandmo (1998) shows that MCF is smaller than one when leisure is a normal good and taxation distort the supply of labor. An increase in uniform transfers lowers the supply of labor, and hence, expands the distortion. The value of money in the public sector is consequently reduced below the average marginal utility of money in the private sector, which implies that MCF is smaller than one.

Most large welfare state countries however offer social transfers to targeted groups like e.g. disabled, sick and old aged. Such targeted transfers distort labor force participation, but is likely to improve welfare as less tax revenue are required to provide for the poor, see Akerlof (1978). Welfare maximizing targeted transfers should be set to eliminate inequality in the average social marginal value of income between tagged groups, see e.g. Viard (2001)[1]. Such transfers may however include negative transfers. Most countries exclude negative transfers, or lump-sum taxes, from their tax system to avoid potential social turmoil and riots connected to lump-sum taxes[2]. The average social marginal value of income for the poor group is higher than average within solutions where positive lump-sum taxes are excluded and the size of the poor group is sufficiently large according to Slack (2015). Hence, the value of transfers, i.e. the value of public funds, exceeds the average marginal value of money in the private sector when labor supply is unaffected by transfers in this case. This explains why the MCF exceeds one in the present study.

The present study explores how MCF is influenced by extensive margin distortions when targeted social transfers are designed to maximize social welfare. The study contributes to the literature by calculating MCF for the Norwegian and the US economy within scenarios where transfers are non-

[1] Equal average marginal value of income between high- and low-income groups is inconsistent with empirical findings on reported happiness, see Deaton (2008) and Stevenson and Wolfers (2008).

[2] The Thatcher government imposed lump-sum taxes in 1990 in England. It created social turmoil and riots in several cities before it was abandoned later that year. One may argue that tax- credits within real- world tax systems acts as a uniform lump-sum subsidy, which can be reduced without creating social turmoil. This might be true for some countries. Reductions in the US earned income tax credit however collects taxes from low- and middle- income earners only, as the credit is phased out.

negative. The study shows that MCF lies between 1.07 and 1.17 (1.05 and 1.11) in scenarios of the Norwegian (the US) economy when extensive margin distortions are excluded. Implementing extensive margin distortions have a marginal impact on MCF estimates. The intuition is that such distortions contributes to lower the value of public funds. The value of public funds is however preserved as tranfers to non-workers, and tranfers to welfare recipients that choose to work, is adjusted. Calculations of MCF based on the modified Samuelson rule confirm these results. Results are based on a tailor made model framework with a simple specifications of individuals' labor supply decisions, and a simple set of policy tools to facilitate numerical calculations. Hence, results should be interpreted as illustrations of the importance of targeted transfers in the presence of labor force participation choices.

The model framework is presented in section 2. Section 3 present definitions of MCF. Results are presented in section 4, and section 5 concludes.

2. The model framework

The model framework is designed to calculate MCF when a welfare maximizing government allocates public funds to public goods provision. A linear income tax distorts the intensive and extensive margin labor/ leisure choice of individuals. The government is assumed to be able to perfectly separate between two groups of individuals. Individuals within both groups are working. Type 1 individuals are classified as healthy, and do not qualify for social transfers. Type 2 individuals are classified as disabled, and hence, is eligible for targeted social transfers. Transfers to non-working within the disabled group distort the extensive margin labor/ leisure choice. Transfers to working individuals within the disabled group contribute to neutralize this distortion.

Positive lump-sum taxes are excluded from the model framework. Costs connected to social turmoil due to lump-sum taxes are also excluded. These exclusions represent the outcome of a welfare maximizing solution when costs connected to social turmoil due to positive lump-sum taxes are sufficiently large.

2.1. The behavior of individuals

There are two types of individuals in the economy with preferences for leisure, l_i, private consumption, c_i, and consumption of public goods, z. Utility functions are identical for all individuals except for one feature. Type 2 individuals experience a loss of utility connected to entering the labor market. This loss differs between type 2 individuals. Utility functions are quasilinear for consumption above a given level, $\hat{c}$.

Individuals of type 1 and 2 differ with respect to productivity, which is given by their respective wage rates, w_i. All n_1 type 1 individuals are working. The higher type 1 wage rate implies a consumption level which exceeds $\hat{c}$. The utility function of type 1 individuals for consumption levels above $\hat{c}$, u_1, are given by

(1) $$u_1 = c_1 + g(l_1) + f(z).$$

The quasilinear utility function is chosen because the labor supply responsiveness of married women due to their husbands' wage change is declining in the US, see Blau and Kahn (2007), and because estimates of the income elasticity on the supply of labor are close to zero in Norway, see Thoresen and Vattø (2015). Both $f(z)$ and $g(l_1)$ are increasing and strictly concave. Consumption is given by after tax wage income, where w_1 equals the wage rate of type 1 individuals, h_1 equals hours of work, and t equals the tax rate

(2) $$c_1 = (1-t)w_1 h_1.$$

The price of consumer goods is normalized to one. The time constraint of type 1 individuals is given by

(3) $$h_1 = T - l_1.$$

Individuals of type 1 maximize their utility, given by equation (1), conditional on their budget equation (2), and their time constraint, equation (3). First order conditions of this optimization problem imply that

(4) $$\lambda = 1.$$

The marginal utility of income, λ, equals one for all levels of consumption above $\hat{c}$.

(5) $$\frac{\partial g}{\partial l_1} = (1-t)w_1$$

The marginal rate of substitution between leisure and private consumption equals the after- tax wage rate. The quasi linear utility function implies that leisure is given by the tax rate, *t*.

(6) $$l_1 = l_1(t) \qquad \frac{\partial l_1}{\partial t} \geq 0$$

This illustrates the intensive margin distortion of the labor income tax. The marginal welfare cost of raising tax revenue by increasing the labor income tax exceeds one with such preferences. The indirect utility of type 1 individuals equals

(7) $$v_1 = (1-t)w_1(T - l_1(t)) + g(l_1(t)) + f(z).$$

Note that the choice of leisure is not influenced by the income effects of taxation. This assumption excludes tax base effects due to income effects, but simplifies calculations of MCF.

The number of type 2 individuals equals n_2, and the number of working type 2 individuals equals n_{2w}. Type 2 individuals with a sufficiently low loss of utility connected to entering the labor market, are assumed to choose a fixed number of working hours, $\overline{h}_2$. This assumption is based on empirical observations which uncover that almost no worker chooses low annual or weekly hours of work, see Eissa et al. (2004). Discrete entry is typically explained by fixed costs (both emotional and fixed working costs) connected to enter the labor market, e_i, which differ between individuals, see Cogan (1981). Consumption of working type 2 individuals exceeds $\hat{c}$, Hence, preferences of type 2 individuals are represented by the utility function, u_2,

(8) $$u_{2w,i} = c_{2w} + g(l_{2w}) - e_i + f(z),$$

Their accumulated cost of entering the labor market equals

(9) $$\frac{1}{2}\alpha n_{2w}{}^{2}$$

Hence, the working disabled with the highest entry cost equals αn_{2w}. α is a parameter which determines the size of the entry cost. Working type 2 individuals receive a transfer, a, from the government. Consumption is given by

(10) $$c_{2w} = (1-t)w_2\bar{h}_2 + a$$

Their indirect utility is given by

(11) $$v_{2w,i} = (1-t)w_2\bar{h}_2 + a + g(\bar{l}_2) - e_i + f(z)$$

The labor supply for type 2 individuals with a sufficiently high disutility for working equals zero. Hence, consumption of non-working type 2 individuals equals transfers, b.

(12) $$c_{2nw} = b$$

These transfers can be lower than $\hat{c}$. Hence, the indirect utility of non-working type 2 individuals is given by

(13) $v_{2nw} = S(b) + g(T) + f(z)$, where S' > 1 and S'' < 0 when $c_{2nw} < \hat{c}$.

The marginal utility derived from public good provision is equalized between all individuals. The study also assume that productivity and tax revenue generated is unaffected by the provision of public goods. These assumptions are crucial for results, see Sandmo (1998) and Kaplow (1996).

The equilibrium condition which determines the number of working type 2 individuals is given by

(14) $$(1-t)w_2\overline{h}_2 + a + g(\bar{l}_2) - \alpha n_{2w} = S(b) + g(T).$$

Equation (14) illustrates how income taxation and transfers to non-working disabled distorts the extensive margin labor/ leisure choice. Transfers to working disabled however contribute to neutralize extensive margin distortions. Equation (14) determines n_{2w} as a function of t, b and a.

(15) $$n_{2w} = n(t,b,a)$$

The specification of utility functions implies that there are no potential welfare gains connected to redistributing income between working individuals.

2.2 The government's optimization problem

The government maximizes an individualistic social welfare function given the budget constraint of the government. The welfare function is found by multiplying indirect utility functions, equation (7), (11) and (13) with the relevant number of individuals, equation (15).

(16)

$$\underset{z,t,b,a}{Maks}\, n_1\left[(1-t)w_1(T-l_1(t)) + g(l_1(t)) + f(z)\right] + n(t,b,a)\left[(1-t)w_2\overline{h}_2 + a + g(\bar{l}_2)\right] - \frac{1}{2}\alpha(n(t,b,a))^2 +$$
$$(n_2 - n(t,b,a))(S(b) + g(T)) + \overline{N}f(z)$$

Given the budget constraint

(17) $$n_1 t w_1(T-l_1(t)) + n(t,b,a)tw_2\overline{h}_2 = qz + (n_2 - n(t,b,a))b + n(t,b,a)a.$$

The Lagrangian is given by

(18)

$$L = n_1\left[(1-t)w_1(T - l_1(t)) + g(l_1(t)) + f(z)\right] + n(t,b,a)\left[(1-t)w_2\overline{h}_2 + a + g(\bar{l}_2)\right] - \frac{1}{2}\alpha(n(t,b,a))^2 +$$

$$(n_2 - n(t,b,a))(S(b) + g(T)) + \overline{N}f(z)$$

$$+ \mu\left[n_1 t w_1(T - l_1(t)) + n(t,b,a)tw_2\overline{h}_2 - qz - (n_2 - n(t,b,a))b - n(t,b,a)a\right].$$

The price of public goods measured in units of private consumer goods equals q, and the shadow value of public funds is denoted μ . Restrictions on $g(l_1)$, $l_1(t)$, $f(z)$ and $S(b)$ imply that the Lagrangian is concave, see appendix A. The first order conditions and calculations of MCF are presented in appendix B. Key equations to estimate MCF is presented below.

3. MCF measures

The MCF is defined as the shadow value of public funds divided by the average marginal utility of income, $\overline{\lambda}$, in most recent studies. The $\overline{\lambda}$ - parameter is necessary in the definition to convert the welfare effect of public funds into units of income, which is measured in terms of consumption goods. Hence, the MCF can be interpreted as the marginal rate of substitution between private and public income, i.e. the number of goods consumed by privates the government is willing to forgo to increase the consumption of public goods with one. The MCF defined as the shadow value of public funds divided by the average marginal utility of income is presented in equation (19).

(19) $$MCF = \frac{\mu}{\overline{\lambda}}$$

The shadow value of public funds is determined by the intensive margin labor supply elasticity and the income tax rate, see appendix B:

(20) $$\mu = \frac{1}{\left[1 - \frac{\partial h_1}{\partial w}\frac{w}{h_1}\frac{t}{(1-t)}\right]}.$$

where the after- tax wage rate equals $w=(1-t)w_1$. μ tends to unity when the intensive margin labor supply elasticity tends to zero.

The average marginal utility of income, which is the denominator on the right- hand side of equation (19), is given by equation (21).

(21) $$\bar{\lambda}=\frac{n_1+n_{2w}+(n_2-n_{2w})\frac{\partial S}{\partial b}}{n_1+n_2}$$

The average marginal utility of income is determined by labor force data and the marginal utility of income for non-working disabled, $\frac{\partial S}{\partial b}$, given by:

(22) $$\frac{\partial S}{\partial b}=\frac{\left[1-\frac{\frac{\partial n}{\partial b}(b-a+tw_2\bar{h}_2)}{\bar{N}-N(t,b,a)}\right]}{\left[1-\frac{\partial h_1}{\partial w}\frac{w}{h_1}\frac{t}{(1-t)}\right]}>1 \text{ if } \frac{\partial h_1}{\partial w}>0,\ t>0,\ \frac{\partial n}{\partial b}<0 \text{ and } b>a-tw_2\bar{h}_2,$$

Equation (22) shows that there are two reasons why transfers to non-working disabled are restricted so that their marginal utility of income exceeds one. First, collecting tax revenue to finance such transfers distorts the intensive margin labor/ leisure choice of working individuals. This effect is given by the denominator on the right- hand side of equation (22). Second, transfers distort the extensive margin labor/ leisure choice of disabled, given by the numerator on the right- hand side of equation (22).

The optimal choice of transfers to working disabled, a, is chosen so that the welfare gains due to entry are balanced against the welfare cost of collecting and redistributing tax revenue.

(23) $$\mu\frac{\partial n}{\partial a}(b-a+tw_2\bar{h}_2)=\mu n(t,b,a)-n(t,b,a)$$

The right- hand side of (23) equals the cost of a marginal increase in public funds spent on transfers to working disabled, μn_{2w}, minus the direct increase in utility of working disabled, which equals n_{2w}, cf. equation (15). This equals the left- hand side, which is the welfare gain related to the drop in transfers to disabled as several disabled decide to enter the labor force, $\mu \frac{\partial n}{\partial a}(b - a + tw_2 \bar{h}_2)$. Inserting the solution for a into Equation (22) determines the marginal utility of income for non-working disabled, $\frac{\partial S}{\partial b}$ as a function of labor force data and the shadow value of public funds, μ.

(24) $$\frac{\partial S}{\partial b} = \frac{\mu(n_2 - n(t,b,a))}{n_2 - \mu n(t,b,a)}$$

Equation (19), (20), (21) and (24) determines MCF defined by equation (19) as a function of labor force data, the intensive margin labor supply elasticity, and the income tax rate.

The study also calculates MCF based on the modified Samuelson rule. This modified Samuelson rule is found by adding consumers' marginal rate of substitution between private and public goods, MRS_{zc}, and setting this equal to the marginal rate of transformation, MRT_{zc}, multiplied with the welfare maximizing cost- adjusting factor, MCF_{ms}. This approach excludes shortcomings connected to various definitions of MCF, see Jacobs (2018). A comparison with the definition in equation (19) is however useful for interpretation of results.

(25) $$(n_1 + n_{2w})\frac{\partial f}{\partial z} + (n_2 - n_{2w})\frac{\frac{\partial f}{\partial z}}{\frac{\partial S}{\partial b}} = MCF_{ms} q,$$

Calculations, which are presented in appendix C, imply that

(26) $$MCF_{ms} = \frac{\mu}{\dfrac{n_1 + n_{2w} + (n_2 - n_{2w})\dfrac{\partial S}{\partial b} + \left(\dfrac{\partial S}{\partial b} - 1\right)(n_1 + n_{2w})}{n_1 + n_2 + \left(\dfrac{\partial S}{\partial b} - 1\right)(n_1 + n_{2w})}}.$$

The left- hand side of equation (25) equals the accumulated marginal rate of substitution between private and public goods. The right- hand side equals the marginal rate of transformation, q, multiplied with the welfare maximizing marginal cost of public funds, MCF_{ms}. Inserting equation (21) into equation (19), and comparing this expression with equation (26) shows that these two approaches differ slightly when the marginal utility of income for the poor group exceeds one. Equation (24) into equation (26) implies that

(27) $$MCF_{ms} = \frac{n_2 + n_1\mu}{n_2 + n_1}.$$

It follows directly from equation (27) that MCF_{ms} is larger than one when the vaue of public funds, μ, exceeds one.

3.1. No extensive margin distortions

This section calculates MCF when taxation distorts the intensive margin choice of labor supply, but not extensive margin choices. The scenario is implemented into the model framework by assuming that the disutility of entering the labor market is substantial for all individuals in the poor group, i.e. α is large.

The first order condition w.r.t. t implies that the marginal welfare cost of raising tax revenue by increasing the tax rate on labor income equals the shadow value of the government budget constraint, μ. This welfare cost, which is determined by equation (20), exceeds one when taxation distorts the supply of labor. Equation (14) implies that the number of working disabled becomes marginal when the disutility of working is substantial. Hence, equation (24) implies that $\partial S / \partial b$ is approaching μ when the number of working disabled is approaching zero. Hence,

(28) $$\frac{\partial S}{\partial b} = \mu \quad .$$

Equation (28) and the first order condition w.r.t. the supply of public goods imply that

(29) $$\frac{(n_1 + n_2)\dfrac{\partial f}{\partial z}}{q} = \frac{\partial S}{\partial b} = \mu \; .$$

Equation (29) shows that the marginal welfare cost of raising tax revenue, μ, equals the marginal welfare gain of redistributing tax revenue, $\partial S / \partial b$, in optimum. The alternative way to spend public funds has to matches this welfare gain. Hence, the marginal welfare cost of raising tax revenue equals the marginal welfare gain of public goods provision. This marginal welfare gain exceeds the resource cost of public goods provision as the cost of raising tax revenue exceeds one.

The implication for MCF is however more complex as “marginal welfare gains” is measured as “willingness to forgo private income/consumption” within cost- benefit studies. Hence, the marginal welfare gain of public goods is transformed to the governments’ willingness to sacrifice private consumption for one additional unit of public goods by dividing with the average marginal utility of income, $\bar{\lambda}$. Hence, equation (29) is transformed to

(30) $$\frac{(n_1 + n_2)\dfrac{\partial f}{\partial z}}{\bar{\lambda}} = MCFq \quad .$$

The left- hand side of equation (30) is a measure of the governments’ willingness to pay for public goods measured in units of the private goods. This equals the marginal rate of transformation between public and private goods, q, multiplied with MCF defined as the governments' marginal rate of substitution between money in the public and the private sector. The shadow value of public funds, μ, is given by equation (20). Equation (19), (21), (28) and $n_{2w} = 0$ implies that

$$\text{(31)} \qquad MCF = \frac{\mu}{\frac{n_1 + n_2\mu}{n_1 + n_2}} > 1.$$

The MCF exceeds one as the value of public funds, μ, exceeds the average marginal utility of income, $\bar{\lambda}$. The numerator in the definition of MCF, μ, equals the welfare gain of transferring public funds to non- working disabled, $\partial S / \partial b$. This gain exceeds the average marginal utility of income. Hence, the MCF exceeds one in this case to match the higher welfare gain of transfers to non- working. The willingness to pay for public goods measured in units of private consumer goods, the left- hand side of equation (30), is reduced as the average marginal utility of income is increased. The reduction in MCF, on the right- hand side, is however identical. The formula for MCF_{ms} is identical with the formula in equation (26). Hence, extensive margin distortions do not influence calculations of MCF based on the modified Samuelson rule. Note that the formula for MCF_{ms} resembles the formula for MCF based on the definition in equation (19). Hence MCF_{ms} exceeds one for the same reasons as for MCF based on equation (19).

4. Results

This section calculates MCF for a large welfare state country, Norway, and a small welfare state country, the US. Most countries will have a relative size of the welfare state between these two countries. The special case where taxation does not distort the extensive margin labor choice is presented in section 4.1. Section 4.2 presents results when taxation distorts both intensive and extensive margins. Results within each scenario are calibrated to labor force data to illustrate the impact on MCF. It is assumed that parameters and functional forms are calibrated so that different solutions fit with data on stocks of individuals within each group, and relevant labor supply responses. The difference between these scenarios should not be interpreted as changes generated by policy, as such changes in policy may alter labor force outcomes.

4.1. Intensive margin distortions

This section report results for scenarios where taxation distorts the intensive margin choice of labor supply, but not extensive margin choices. Labor force data is presented in table 1, see also appendix D. Scenarios with intensive margin labor supply elasticity's of 0.1 and 0.2 for the US and Norway are presented3. The total tax rate on labor income is found by an assessment of the tax system within each country. Table 1 reports scenarios where MCF approximately equals 1.1 and 1.05 for the US with an intensive margin labor supply elasticity of 0.2 and 0.1, respectively. Estimates for Norway are slightly higher mainly due to a higher tax rate4.

Table 1. Labor force data and MCF for Norway and the US, no extensive margin distortions

Country	n_1	n_2	n_{2w}	$El_w h$	t	μ	$\frac{\partial S}{\partial b}$	MCF = μ/λ	MCF_{ms}
Norway	2,619	1,349	0	0,1	0,5	1,111	1,111	1,07	1,07
Norway	2,619	1,349	0	0,2	0,5	1,25	1,25	1,15	1,17
USA	156,76	70	0	0,1	0,4	1,071	1,071	1,05	1,05
USA	156,76	70	0	0,2	0,4	1,154	1,154	1,10	1,11

4.2. Intensive and extensive margin distortions

This section report results for scenarios where taxation distorts both the intensive and the extensive margin choice of labor supply. The MCF is determined by equation (19), (20), (21) and (24). Equation (20) and (23) implies that $b > a - tw_2\overline{h}_2$, i.e. that transfers to non- working in the disabled group is larger than transfers net of taxes for working individuals in the disabled group. This result combined with equation (20) and (22) implies that $\partial S/\partial b > 1$. Note that Saez (2002) find that income should be taxed with negative rates at low income levels to stimulate labor force participation.

[3] Note that the uncompensated labor supply elasticity equals the compensated labor supply elasticity with quasilinear preferences. Empirical estimates of the uncompensated elasticity are close to zero. Hence, the compensated elasticity has to be close to zero.

[4] Note that calculations based on Stone-Geary utility generates almost identical MCF estimates. Hence, assuming quasilinear preferences is not crucial for these results.

Data on how many disabled (and others on social welfare) that are working is required to calculate MCF in this case. The value of n_{2w} is obtained by assessments of data even though n_{2w} is an endogenous variable within the model framework. It is estimated that approximately 30 percent of individuals with severe disability within EU countries chose to work, see Eurostat (2001). A substantial share of these individuals receives social welfare benefits. It is however difficult to pinpoint the exact number. Two scenarios are analyzed where 10 and 20 percent of individuals classified as disabled are in the workforce. These individuals are assumed to be included in the labor force when data is presented. Results and adjusted labor force date is presented in table 2. The shadow value of public funds equals approximately 1.11 and 1.25 (1.07 and 1.15) when the tax rate equals 0.5 (0.4) and the intensive margin labor supply elasticity equals 0.1 and 0.2, respectively. The shadow value of public funds is not influenced by extensive margin distortions because distortion created by the income tax can be completely neutralized by adjustments in transfers to working disabled. Hence, results are not sensitive to changes in the extensive margin labor supply elasticity.

Table 2. Labor force data and MCF for Norway and the US, intensive and extensive margin distortions

Country	n_1	n_2	n_{2w}	$El_w h$	t	μ	$\frac{\partial S}{\partial b}$	MCF = μ/λ	MCF_{ms}
Norway 20 %	2,282	1,686	0,337	0,1	0,5	1,111	1,143	1,06	1,06
Norway 10 %	2,47	1,5	0,15	0,1	0,5	1,111	1,125	1,07	1,07
USA 20 %	139,26	87,5	17,5	0,1	0,4	1,071	1,090	1,04	1,04
USA 10 %	148,98	77,78	7,78	0,1	0,4	1,071	1,0795	1,05	1,05
Norway 20 %	2,282	1,686	0,337	0,2	0,5	1,25	1,333	1,12	1,14
Norway 10 %	2,47	1,5	0,15	0,2	0,5	1,25	1,286	1,14	1,16
USA 20 %	139,26	87,5	17,5	0,2	0,4	1,154	1,200	1,09	1,10
USA 10 %	148,98	77,78	7,78	0,2	0,4	1,154	1,174	1,10	1,10

Table 2 report estimates of MCF below 1.11 for the US economy. Estimates for the Norwegian economy are below 1.16. The formula for MCF_{ms} is identical with the formula in equation (26). Hence, extensive margin distortions do not influence calculations of MCF based on the modified Samuelson rule. The explanation is that such distortions contributes to lower the value of public funds. The extensive margin distortion is only partly neutralized by transfers to working individuals in the poor group because collecting tax revenue to finance transfers create distortions in the intensive margin labor/ leisure choice of working individuals. Hence, it is optimal to scale down on redistribution to non- working to prevent both intensive and extensive margin distortions. The reduction in transfers increases the marginal utility of income for welfare recipients. The higher marginal utility of income contributes to increase, and hence, restore the value of public funds. Note that the formula for MCF_{ms} resembles the formula for MCF based on the definition in equation (19). Hence MCF_{ms} exceeds one for the same reasons as for MCF based on equation (19).

5. Conclusion

Kleven and Kreiner (2006) estimate that the marginal cost of public funds (MCF) equals 2.20 within basic scenarios of the Danish economy when taxation distorts labor force participation. Kleven and Kreiner (2006), however, do not consider welfare maximizing solutions where social transfers to non-workers, or transfers to social welfare recipients that decide to work, alleviate such distortions. The present study explores how MCF is influenced by extensive margin distortions when targeted social security transfers redistribute income so that the welfare is maximized. The study shows that MCF within the US and the Norwegian economy should be in the interval 1.04-1.16 when social transfers alleviate such distortions. The study also shows that extensive margin distortions have a marginal impact on MCF estimates when taxation is combined with such social transfers.

The vast literature on MCF consists of a range of contributions which deserve to be mentioned. A discussion and assessment of all important contributions is however beyond the scope of the present study. The study illustrates the importance of the marginal welfare gain of the alternative use of public funds. The alternative use is crucial as the marginal welfare gain of public goods provision have to match the welfare gain of this alternative use within optimized solutions. Hence, future research could reexamine previous results on MCF when the alternative use of public funds is considered in more detail. Future research could e.g. examine the impact on MCF when social transfers is combined with employment programs, social security fraud and mobility between tagged groups, see Parson (1996) and Jacquet (2014).

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Appendix:

A. The second order condition:

The second order condition is satisfied if the Lagrangian is concave. This condition is satisfied if second order derivatives are negative, and that second order derivatives dominate over cross derivatives within conditions for concavity.

$$(\text{A 1})\ \frac{\partial^2 L}{\partial z \partial z} = (n_1 + n_2)\frac{\partial^2 f}{\partial z \partial z} < 0$$

$$(\text{A 2})\ \frac{\partial^2 L}{\partial t \partial t} = (1-\mu)n_1 w_1 \frac{\partial l_1}{\partial t} + (1-\mu)n_1 w_1 \frac{\partial l_1}{\partial t} - (1-\mu)w_2 \overline{h}_2 \frac{\partial n}{\partial t} + n_1 \frac{\partial^2 g}{\partial l_1 \partial l_1}\frac{\partial l_1}{\partial t}\frac{\partial l_1}{\partial t}$$

$$+ \mu w_2 \overline{h}_2 \frac{\partial n}{\partial t} - \mu n_1 t w_1 \frac{\partial^2 l_1}{\partial t \partial t} < 0 \text{ if } \mu \geq 1,\ t \geq 0 \text{ and } \frac{\partial^2 l_1}{\partial t \partial t} \geq 0 .$$

$$(\text{A 3})\ \frac{\partial^2 L}{\partial b \partial b} = \frac{\partial^2 S}{\partial b \partial b}\left[n_2 - n(t,b,a)\right] + \frac{1}{\alpha}\frac{\partial S}{\partial b}\frac{\partial S}{\partial b} - \frac{\mu}{\alpha}\left[\frac{\partial^2 S}{\partial b \partial b}(b - a + t w_2 \overline{h}_2) + \frac{\partial S}{\partial b}\right] < 0 \text{ if } \alpha \text{ is}$$

sufficiently large.

$$(\text{A 4})\ \frac{\partial^2 L}{\partial a \partial a} = (1-\mu)\frac{1}{\alpha} < 0 \text{ if } \mu > 1.$$

Results are limited to cases where these second order derivatives dominate over cross derivatives within conditions for concavity.

B. The first order conditions:

The Envelope Theorem is employed to calculate the impact of a marginal change in the tax rate. The equilibrium condition which determines the number of disabled that are working is employed to calculate the impact of a marginal change in transfers.

$$(\text{B 1})\ \frac{\partial L}{\partial z} = (n_1 + n_2)\frac{\partial f}{\partial z} - \mu q = 0$$

$$(\text{B 2})\ \frac{\partial L}{\partial t} = n_1\left[-w_1(T - l_1(t))\right] - n_1\left[(1-t)w_1\frac{\partial l_1}{\partial t} - \frac{\partial g}{\partial l_1}\frac{\partial l_1}{\partial t}\right] + n(t,b,a)(-w_2\overline{h}_2)$$

$$+ \frac{\partial n}{\partial t}\left[\left[(1-t)w_2\overline{h}_2 + a + g(\bar{l}_2)\right] - \alpha n(t,b,a) - (S(b) + g(T))\right]$$

$$+ \mu\left[n_1 w_1 (T - l_1(t)) - \frac{\partial l_1}{\partial t} n_1 t w_1 + n(t,b,a) w_2 \overline{h}_2 + \frac{\partial n}{\partial t} t w_2 \overline{h}_2 + \frac{\partial n}{\partial t} b - \frac{\partial n}{\partial t} a\right] = 0$$

(B 3) $\frac{\partial L}{\partial b} = \frac{\partial n}{\partial b}\left[\left[(1-t)w_2\bar{h}_2 + a + g(\bar{l}_2)\right] - \alpha n(t,b,a) - (S(b)+g(T))\right] + \frac{\partial S}{\partial b}(n_2 - n(t,b,a)) -$

$\mu\left[n_2 - n(t,b,a) - \frac{\partial n}{\partial b}tw_2\bar{h}_2 - \frac{\partial n}{\partial b}b + \frac{\partial n}{\partial b}a\right] = 0$

(B 4)

$\frac{\partial L}{\partial a} = \frac{\partial n}{\partial a}\left[\left[(1-t)w_2\bar{h}_2 + a + g(\bar{l}_2)\right] - \alpha n(t,b,a) - (S(b)+g(T))\right] + n(t,b,a)$

$+\mu\left[\frac{\partial n}{\partial a}tw_2\bar{h}_2 - n(t,b,a) + \frac{\partial n}{\partial a}(b-a)\right] = 0$

The budget constraint implies that

(B 5) $n_1 tw_1(T - l_1(t)) + n(t,b,a)tw_2\bar{h}_2 = qz + (n_2 - n(t,b,a))b + n(t,b,a)a$

Hence, equation (B 1) gives

(B 6) $(n_1 + n_2)\frac{\partial f}{\partial z} = \mu q$

Equation (14) implies that $\frac{\partial n}{\partial a} = \frac{\partial n}{\partial t}\left(\frac{-1}{w_2\bar{h}_2}\right)$. This expression combined with equation (B 2) and (B4) gives

(B 7) $\mu = \frac{1}{\left[1 - \frac{\frac{\partial l_1}{\partial t}tw_1}{w_1(T - l_1(t))}\right]} > 1$ if $\frac{\partial l_1}{\partial t} > 0$ and $t > 0$.

Equation (B 3) gives

(B 8) $\frac{\partial S}{\partial b} = \mu\left[1 - \frac{\frac{\partial n}{\partial b}(b - a + tw_2\bar{h}_2)}{n_2 - n(t,b,a)}\right]$

Equation (B 4) gives

(B 9) $(1-\mu)n(t,b,a) + \mu\frac{\partial n}{\partial a}(b - a + tw_2\bar{h}_2) = 0$

The numerical illustration, however, require some additional calculations. First, the definition of leisure,

(B 10) $l_1 = T - h_1$,

imply that

(B 11) $\frac{\partial l_1}{\partial t} = -\frac{\partial h_1}{\partial t}$

Second, the definition of the after tax wage rate,

(B 12) $w = (1-t)w_1$,

imply that

(B 13) $\frac{\partial w}{\partial t} = -w_1$

Equation (B 10)-(B 13), together with the definition

(B 14) $-\frac{\partial h_1}{\partial t} = -\frac{\partial h_1}{\partial w}\frac{\partial w}{\partial t}$

Imply that

(B 15) $\frac{\partial l_1}{\partial t} = w_1 \frac{\partial h_1}{\partial w}$

Inserting (B12) and (B 15) into equation (B 7) gives

(B 16) $\mu = \frac{1}{\left[1 - \frac{\partial h_1}{\partial w}\frac{w}{h_1}\frac{t}{(1-t)}\right]}$

The marginal utility of income for non-working disabled, $\frac{\partial S}{\partial b}$, is included in the formula for the average marginal utility of income. Equation (B 9) implies that

(B 17) $\frac{\partial n}{\partial a}(b - a + tw_2\bar{h}_2) = \frac{-(1-\mu)}{\mu} n(t,b,a)$

Equation (14) implies that $\frac{\partial n}{\partial a} = \frac{\partial n}{\partial b}\left(\frac{1}{-\frac{\partial S}{\partial b}}\right)$. This expression combined with equation (B 17) gives

(B 18) $\frac{\partial n}{\partial b}(b - a + tw_2\bar{h}_2) = \frac{(1-\mu)}{\mu} n(t,b,a)\frac{\partial S}{\partial b}$

Equation (B 18) into equation (B 8) gives

(B 19) $\frac{\partial S}{\partial b} = \frac{\mu(n_2 - n(t,b,a))}{n_2 - \mu n(t,b,a)}$

Equation (B 16), (B 19) and (21) determines MCF as a function of labor force data, the intensive margin labor supply elasticity, and the income tax rate.

C. MCF based on the modified Samuelson rule

The point of departure is the first order equation (B 6)

$$\text{(D 1)}\ (n_1 + n_2)\frac{\partial f}{\partial z} = \mu q$$

Hence,

$$\text{(D 2)}\ (n_1 + n_{2w})\frac{\partial f}{\partial z} + (n_2 - n_{2w})\frac{\partial f}{\partial z} = \mu q$$

Hence,

$$\text{(D 3)}\ (n_1 + n_{2w})\frac{\partial f}{\partial z} + (n_2 - n_{2w})\frac{\frac{\partial f}{\partial z}}{\frac{\partial S}{\partial b}} + (n_2 - n_{2w})\frac{\frac{\partial f}{\partial z}}{\frac{\partial S}{\partial b}}(\frac{\partial S}{\partial b} - 1) = \mu q$$

Hence,

$$\text{(D 4)}\ (n_1 + n_{2w})\frac{\partial f}{\partial z} + (n_2 - n_{2w})\frac{\frac{\partial f}{\partial z}}{\frac{\partial S}{\partial b}} = \mu q - (n_2 - n_{2w})\frac{\frac{\partial f}{\partial z}}{\frac{\partial S}{\partial b}}(\frac{\partial S}{\partial b} - 1)$$

Substituting $\frac{\partial f}{\partial z}$ on the right hand side with equation (D 1) gives

$$\text{(D 5)}\ (n_1 + n_{2w})\frac{\partial f}{\partial z} + (n_2 - n_{2w})\frac{\frac{\partial f}{\partial z}}{\frac{\partial S}{\partial b}} = \left[\mu - \mu\frac{\frac{(n_2 - n_{2w})}{(n_1 + n_2)}}{\frac{\partial S}{\partial b}}\left(\frac{\partial S}{\partial b} - 1\right)\right]q$$

Hence,

$$\text{(D 6)}\ (n_1 + n_{2w})\frac{\partial f}{\partial z} + (n_2 - n_{2w})\frac{\frac{\partial f}{\partial z}}{\frac{\partial S}{\partial b}} = \frac{\mu}{\frac{n_1 + n_{2w} + (n_2 - n_{2w})\frac{\partial S}{\partial b} + \left(\frac{\partial S}{\partial b} - 1\right)(n_1 + n_{2w})}{n_1 + n_2 + \left(\frac{\partial S}{\partial b} - 1\right)(n_1 + n_{2w})}}q$$

Hence, MCF_{ms} is given by the expression

$$\text{(D 6)}\ MCF_{ms} = \frac{\mu}{\frac{n_1 + n_{2w} + (n_2 - n_{2w})\frac{\partial S}{\partial b} + \left(\frac{\partial S}{\partial b} - 1\right)(n_1 + n_{2w})}{n_1 + n_2 + \left(\frac{\partial S}{\partial b} - 1\right)(n_1 + n_{2w})}}$$

D. Labor force data

The case of US is illustrated by implementing data for 2013. The number on social disability transfers (app. 9 mill according to Social security administration), unemployment (8 million in 2015 according to the US Department of labor), on Medicare (50 million according to the Kaiser Family foundation), and public pensions (Estimate of 3 million). The total number on social benefit transfers, n_2, amounts to 70 million. The number of employed amounts to 156.76 million individuals according to OECD. Sensitivity tests are conducted which excludes people on Medicare from the group on social benefit transfers. The impact on MCF is modest.

The case of Norway is illustrated by implementing data for 2013. The number on social disability transfers, unemployment benefit, sickness transfers and public pensions, n_2, amounts to 1349 thousand. The total number of working individuals, n_1, amounts to 2619 thousand. One may however argue that individuals on public pension should be excluded from the disabled group as many have accumulated wealth that can be consumed. This wealth effect as well as their desire to consume may depress their marginal utility of income.

The income tax wedge on average income earners amounts to 31.5 percent in the US, and 37 percent in Norway in 2014 according to OECD. The sales tax ranges from 0 to almost 10 percent in the US. VAT on most consumer goods in Norway equals 25 percent. There is also substantial taxation of corporate income in both countries, as well as real estate taxation in the US. Immervoll et al. (2007) report total marginal tax rates above 60 percent for other Nordic countries. Total tax revenue as a share of GDP only amounts to 25.4 percent of GDP in the US and 40.8 percent in Norway in 2013 according to OECD. The average tax rate on labor earnings is larger as the tax on capital earnings is lower. The effective tax rate on labor earnings is also influenced by public spending, tax deductions and tax evasion. Tax payments to finance public pensions in Norway resemble mandatory savings schemes, as income tax payments are linked with pension transfers. Hence, one may argue that such taxes should be exempted from the effective marginal tax rate. One may also argue that certain types of public spending function as subsidies on private consumption. Public roads may for example function as a subsidy on the purchase of cars. Public education stimulates investment in human capital, and hence, earnings. It is however difficult to determine the exact impact on the effective marginal tax rate. An overall assessment suggests that the total effective tax rate on labor earnings amounts to approximately 40 percent in the US, and 50 percent in Norway.

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