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The Mainstream Notion of ‘Deadweight Loss of Taxation’ Is Based on Too Stringent (Misleading) Assumptions¹

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March 2020

Abstract

Mainstream optimal tax theory considers the lump-sum tax as the only efficient or non-distortionary tax instrument, and as such, the only tax instrument that is never associated with a deadweight loss. This paper challenges this notion, which is shown to depend on the assumption that public expenditure has no effect on taxpayers’ budget constraints. When this assumption is relaxed, the combined use of labor income and lump-sum taxes may allow taxpayers to reach greater levels of welfare than the use of a lump-sum tax alone. In that case, the labor income tax would be part of the (first best) welfare maximization solution and its effect on the relative price of leisure would therefore correspond to a price correction, not a distortion.

Keywords: optimal taxation, deadweight loss, labor income tax, lump-sum tax

JEL codes: H21, H24, J22

¹ This paper is based on Sepulveda (2018), also published in the ICePP Working Paper Series.

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Introduction

Traditional public economic theory asserts that the first best solution to the welfare maximization problem is attainable only if tax revenue is collected exclusively with lump-sum taxes. The use of any other tax revenue source implies that the economy can no longer reach that solution, because it would distort individual behavior. Tax-induced changes in relative prices are generally interpreted as distortions, and all (non-Pigouvian) taxes that affect relative prices are said to create a deadweight loss. Consistent with this position, Atkinson and Stiglitz (1976, p.74) state that “[t]he necessity for any form of taxation different than a uniform lump-sum tax arises from the fact that individuals have different characteristics (endowments or tastes).”¹ This paper challenges this conclusion. Focusing on the labor income tax, it shows that even when taxpayers have identical endowments and tastes – such that distributional considerations are assumed away, the superiority of the lump-sum tax does not necessarily hold when public expenditure affects individuals’ budget constraints.

The case for incorporating the effects of public expenditure on budget constraints in the analysis of the effects of taxation rests on the need to consider the welfare effects of the expenditure programs financed with the taxes collected, as well as on the nature of the goods and services provided by the government. The need to consider the effects of public expenditure has for long been recognized and debated in the fiscal incidence literature.² Even though fiscal

¹ The deadweight loss of taxation is discussed, for instance, in Auerbach and Hines (2002), who provide an overview of optimal tax theory. More recent surveys about optimal income taxation can be found in Boadway (2012) and Sørensen (2010).

² Several approaches have been developed to estimate the incidence of fiscal policies. In particular, the *absolute incidence* approach assumes that the government retains the tax proceeds, so it disregards the expenditure side of the problem. Most other approaches, however, rely on alternative assumptions to consider public expenditure. The *differential incidence* approach compares welfare levels under two tax instruments, one of which is usually the lump-sum tax, while keeping the amount of tax revenue constant (see Fullerton and Metcalf 2002). Under this approach public expenditure plays a rather passive role; ‘no rebates’ can be assumed to represent a situation where public expenditure is inconsequential, ‘rebates’ can be assumed to cancel out income effects or to make the

incidence and the distortionary effects of taxation are patently different problems, focused respectively on redistribution and on efficiency, they share a common theoretical framework because they both aspire to estimate the welfare effects of fiscal policies. In this context, it is rather surprising that, when defining and measuring the deadweight loss of taxation, mainstream theory does not account for all possible effects of public expenditure.

The distortionary effects of a tax instrument, or its deadweight loss, is defined in mainstream theory as the difference between the levels of welfare reached with the *after-tax* budget constraints under that tax instrument and an equal yield lump-sum tax.³ The possible effects of public expenditure on the budget constraints are ignored, and thus the *after-tax-and-expenditure* budget constraints are disregarded. The problem with using after-tax budget constraints is that they are sufficient to fully describe the welfare effects of taxation only in two situations: when public expenditure leads to no benefit to the taxpayer; and when the benefits are perceived solely as higher utility from public goods. An example of the first situation is given by taxes collected only for redistributive purposes.⁴ The second situation, although possible, is not generalizable due to the nature of public goods and services. Many public goods and services, like roads, defense, regulations, etc. are not meant to be enjoyable, and therefore their benefits

measures of welfare closer to the after-tax-and-expenditure levels. Other approaches put more emphasis on the benefits of public expenditure. Under *balanced-budget incidence* analysis the benefits are estimated as the share of the costs assigned to provide services to different income groups, so total benefits must be equal to total costs. This approach is implicit in much of the historical literature on redistribution; for instance, it is the approach used by Buchanan (1950) when defining the fiscal residuum. The distinction between balanced-budget and differential incidence is due to Musgrave (1959). Finally, the *net fiscal incidence* approach (Piggott and Whalley 1987) allows for the welfare benefits of public expenditure to exceed the amount of tax revenue, an argument based on the basic cost-benefit rule stating that the benefits of any worthwhile government program must be greater than its costs.

³ This is equivalent to applying the *differential incidence* approach (without rebates). A discussion about how the deadweight loss is defined in modern economics and a comparison with an alternative “commonsense” notion of deadweight loss –based on the difference between the before-tax and after-tax levels of welfare can be found in Lind and Granqvist (2010).

⁴ It follows that the mainstream conclusion about the superiority of lump-sum taxation is valid for the case of redistributive programs.

cannot be accurately represented by just an increase in utility. Instead, they are meant to increase real income by affecting the parameters that determine the budget constraint (e.g., prices, wage rates, income, time constraints), which in turn will alter labor supply and consumption decisions. Moreover, even public goods that are enjoyable (e.g., parks) can substitute for costly private goods, such that their provision can free up income that is made available to purchase additional private goods. In either case, the budget constraint will likely be affected. Similarly, the public provision of private goods can directly alter the affordability of other private goods and the budget constraint.⁵ In general, whenever public expenditure affects taxpayers' budget constraints, the after-tax levels of welfare are just hypothetical, and the levels that are relevant to welfare analysis are the *before-tax* and the *after-tax-and-expenditure* levels.

Provided that public expenditure shifts the budget constraint, it is easy to show that there is a set of allocations that are affordable under the labor income but not under the lump-sum tax. If the welfare maximizing allocation were in that set, then the labor income tax would be part of the (first best) solution to the welfare maximization problem. In that case, the tax-induced change in the relative price of leisure should not be considered a distortion, but a price correction necessary to obtain a positive net welfare gain.

This conclusion suggests that it is not correct to assume that any tax instrument other than the lump-sum tax will necessarily create a deadweight loss. This has been a fundamental assumption in optimal tax theory, and it has been applied, for instance, to the estimation of the deadweight loss of income taxation and discussions about the optimal size of the government (see Feldstein 1997, 1999). More recently, in what could be considered as a slight departure from

⁵ Private services are understood as services that are both rival and excludable. Relevant examples of private services provided by the public sector are educational and health services.

that tradition, Blomquist et al. (2010) argued that the use of income taxation may be less distortionary when part of the marginal labor income tax corresponds to a payment for publicly provided private goods. In contrast, the argument put forward in the present paper is pertinent to the labor income tax in general, regardless of whether the tax rate can be interpreted as a direct payment for the goods provided. The labor income tax can be part of the first-best solution when taxpayers assign a relatively high value to leisure, such that they are more inclined to sacrifice private consumption in order to enjoy more leisure. In this context, mainstream theory could well be estimating a large deadweight loss where there is none, misleading the analyses of optimal tax systems and the optimal size of the public sector.

The next section describes the basic framework under which the concepts of deadweight loss and marginal efficiency cost of funds are defined by the traditional literature. The third section identifies several possible channels through which public expenditure may shift the budget constraint, and explain that in this case the labor income tax can be part of the welfare maximization solution. The last section provides a brief discussion of the main results.

Deadweight Loss and Marginal Efficiency Cost of Funds: The mainstream approach

This section describes the basic framework in which the deadweight loss and the marginal efficiency cost of funds are defined in mainstream economic theory.

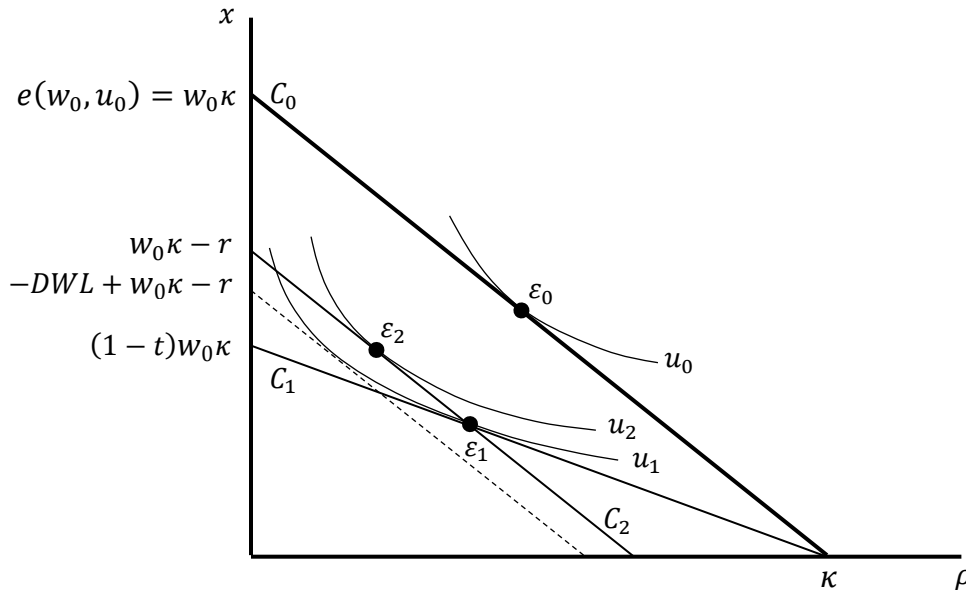
The Mainstream Definition of Deadweight Loss

Consider an economy with identical individuals, such that redistribution is unnecessary and we can focus on efficiency only. The mainstream measure of deadweight loss is described in Figure 1, which displays the preferences and budget constraint of a representative taxpayer. The vertical axis represents a composite private good, x . Leisure ρ increases rightward in the

horizontal axis, where κ is the time constraint and labor is implicitly defined as $l = \kappa - \rho$. The initial equilibrium is at ε_0 , where the initial budget constraint C_0 is tangent to the indifference curve u_0 .

Mainstream optimal tax theory defines the deadweight loss of the labor income tax by comparing its effect on utility with the effect of an equal yield lump-sum tax. A proportional tax rate t on labor income reduces the wage rate to $(1 - t)w_0$, rotating the budget constraint over κ , from C_0 to C_1 . The optimum under t is at ε_1 , associated with a utility level u_1 . A lump-sum tax that raises the same amount of tax revenue r would lead to a different equilibrium at ε_2 , allowing the taxpayer to reach a higher utility level u_2 . Using the expenditure function $e(w_i, u_i)$ to represent the minimum amount of money required to obtain a utility level u_i with a wage rate w_i , the (equivalent variation) measure of deadweight loss associated with the labor income tax can be expressed as $DWL = e(w_0, u_0) - e(w_0, u_1) - r$. In general, the value of the inefficiency or DWL of any tax instrument corresponds to the additional amount of money required to obtain the same level of utility obtained with an equal yield lump-sum tax.

Figure 1: Mainstream Measure of the Deadweight Loss of the Labor Income Tax



The way in which tax revenue is spent is often (but not always) disregarded in the computation of the deadweight loss. If preferences are convex, and the benefits of public expenditure are not taken into account, then $u_0 > u_2 > u_1$. Accounting for the direct welfare benefits of public expenditure does *not* by itself affect the conclusion that tax instruments other than the lump-sum tax are inefficient. For simplicity and comparability, assume that all public expenditures are used to finance non-rival and non-excludable (pure) public goods. We can think about the quantity of public goods as represented by a third dimension not shown in the two-dimensional space of Figure 1. If public goods are weakly separable from private goods and leisure in the utility function, then the shape of the indifference map does not change with the level of public goods and the previous analysis remains valid.⁶ In that case, the amount of public goods would affect only the level of utility represented by each indifference curve. Assuming also that public expenditure has no effect on the budget constraint, a government program that is

⁶ See Browning et al. (2000) for an analysis of the welfare costs of taxation that exploits the weak separability assumption.

worthwhile (with positive net benefits) under the labor income tax would now result in $u_2 > u_1 > u_0$. The measure of *DWL* remains identical to the one described above because the net welfare benefits obtained under the labor income tax are lower than the net welfare benefits obtained under the lump-sum tax.

Marginal Efficiency Cost of Funds

The solution for the optimal amount of public expenditure and the corresponding optimal labor income tax rate is described by the adjusted Samuelson's (1954) condition, which is used to define the concept of marginal efficiency cost of funds. Consider a representative taxpayer that chooses the level of labor supply l that maximizes a general (non-separable) quasi-concave utility function $u\{x, \rho, G\}$, and use m to denote non-labor income. Utility increases with the composite private good $x = (1 - t)wl + m$, leisure $\rho = \kappa - l$, and the provision of a pure public good G , which is considered exogenous by the taxpayer. The taxpayer's first order condition is

$$(1 - t)wu_x = u_\rho, \quad (1)$$

where subscripts represent derivatives with respect to the denoted variable. Labor supply is implicitly defined as $l = l(t, w, m, \kappa, G)$.

A welfare maximizing government is assumed to consider a utilitarian social welfare function defined as the sum of utilities of N identical taxpayers. Assuming that the government budget is balanced, public expenditure must be equal to total tax revenue R , or $G = R = Nr$, where individual tax revenue is $r = twl(\cdot) = r(t, w, m, \kappa, G)$ is now allowed to vary. The government problem can be described by the Lagrangian

$$\Lambda = Nu\{(1 - t)wl(\cdot) + m, \kappa - l(\cdot), G\} + \lambda[-G + Ntwl(\cdot)]. \quad (2)$$

Using (1), the first order conditions for the optimal choices of t and G imply that⁷

$$\frac{R_t}{1-R_G} N u_G = w L u_x, \quad (3.a)$$

where $R_t = N(wl + twl_t)$ is the marginal effect of the tax rate on tax revenue, $R_G = Ntwl_G$ is the marginal effect of public expenditure on tax revenue, and $wL = wNl$ the value of the reduction in aggregate private consumption (net of leisure gains) associated with the tax. This condition means that the government should collect taxes up to the amount at which the benefits of the last dollar spent on public goods, represented by the left-hand side of (3.a), are equal to its costs—the value of the private goods sacrificed, represented by the right-hand side. Rearranging, we obtain

$$N \frac{u_G}{u_x} = \frac{(1-R_G)wL}{R_t}, \quad (3.b)$$

which is a version of the adjusted Samuelson condition describing the optimal provision of public goods. Either (3.a) or (3.b) determine the optimal (total) amount of public expenditure by defining the condition to be satisfied by the *last* dollar spent. Provided that marginal benefits are decreasing in G and marginal costs are increasing in t , for any inframarginal dollar spent the net welfare benefits must be positive, and thus the left-hand side of (3.b) must be greater than the right-hand side.⁸

⁷ The derivation of condition (3.a) is available in the Appendix.

⁸ This point has explicitly been stressed by Piggott and Whalley (1987), who pointed out that it is incorrect to assume that the (total) welfare effects of tax revenues and government expenditures must be equal (as implied by the balanced-budget approach to fiscal incidence).

Net Welfare Benefit Effects of Lump-Sum Taxes and Labor Income Taxes

The objective of this section is to show that, as long as public expenditure affects the budget constraint, the combined use of the labor income tax and the lump-sum tax may allow the taxpayer to reach a higher utility level than the use of the lump-sum tax alone.

Possible Effects of Public Expenditure on Taxpayers' Budget Constraints

Public goods may have not only direct effects on utility, but also indirect effects through the changes they induce in other determinants of taxpayers' purchasing power. For instance, taxpayers do not necessarily enjoy roads; but instead obtain indirect benefits because roads save time. More time available for leisure and labor implies that the time constraint is an increasing function of public goods, such that $\kappa = \kappa(G)$ and $\kappa_G > 0$. In addition, less transportation time reduces the costs of production and distribution, possibly resulting in lower market prices of final goods and greater non-labor income for firms' stockholders. As a result, roads can increase welfare not because they satisfy taxpayers' preferences, but because they lead to an actual increase in taxpayers' real income, which is represented by an outward shift of the budget constraints.

There are several channels through which public goods, and public expenditure in general, can affect the budget constraint. When a government adequately corrects for market failures, we can expect the levels of efficiency and welfare to increase, and it is not difficult to find examples in which taxpayers' real income are affected. The government provides a number of important services like development of the legal framework, enforcement of property rights, regulation of economic activity, etc. Individuals may not enjoy these public goods directly; they could even be unaware or indifferent about them, meaning that their utility levels are not directly affected by a change in the provision of these public goods ($u_G = 0$). It is reasonable to expect

that at least part of the benefits that make these services worthwhile are received in the form of lower transaction costs, lower costs of capital formation and accumulation, or other factors that can positively affect real income. Similarly, when the government intervenes in imperfectly competitive markets, economic efficiency can increase and taxpayers can receive benefits in the form of higher salaries and lower prices of private goods.

The effects of public expenditure on the budget constraint are not limited to unenjoyable public goods. Enjoyable public goods like parks can substitute for private goods that would otherwise be purchased in their absence, freeing up resources that might increase after-tax real income. Private services like education and health can be subject to positive externalities. When the government intervenes in order to take advantage of these externalities, overall economic efficiency increases. If these services are considered as part of a composite private good x (not G), then the net gain in efficiency implies that tax and expenditure policies can lead to an increase in real income and an outward shift of the original budget constraints.

Welfare Gains under the Labor Income Tax

As long as the budget constraint shifts as a consequence of a change in the provision of public expenditure, (first-best) welfare maximization does not preclude the use of the labor income tax. To see this, we take into account the several channels through which public expenditure can affect real income, and redefine the functions determining the goods available to the taxpayer as

$$x = (1 - t)w(G)l(\cdot) + m(G), \quad (4.a)$$

$$\rho = \kappa(G) - l(\cdot), \quad (4.b)$$

$$G = R = Ntw(G)l(\cdot); \quad (4.c)$$

where the wage rate w , non-labor income m , and the time constraint κ are all assumed to be functions of G , and where labor is redefined as $l = l(t, w(G), m(G), \kappa(G), G)$. Considering (4.a-c), the first order conditions for the government's choices of t and G lead to

$$N((1-t)lw_G + m_G + (1-t)w\kappa_G) + N \frac{u_G}{u_x} = \frac{(1-R_G)wL}{R_t}. \quad (5)$$

The optimal condition (5) is analogous to the adjusted Samuelson condition in (3.b).⁹ The left-hand side includes not only marginal welfare benefits of public expenditure, but also the marginal efficiency gains in *private* expenditure.

Graphically, when the government collects and spends a dollar that brings net benefits, if real income increases then the budget constraint would shift outward. The (last) dollar that completes the optimal amount of public expenditure has no net benefit; with that dollar the budget constraint either remains unaffected or, if moves, remains tangent to the same indifference curve (the last dollar leads to no change in utility). If the government keeps collecting and spending money beyond the optimal level and real income is negatively affected, then the budget constraint would shift inward.

In order to illustrate the net effects of public expenditure, assume for simplicity that the representative taxpayer does not exhibit any preference for the public good ($u_G = 0$) and that the effect of a worthwhile government program consists only of an increase of real income equal to m .¹⁰ In this context, a worthwhile government program must allow the taxpayer to reach an

⁹ The derivation of condition (5) is available in the Appendix.

¹⁰ Lewis (1957/1971) and Gwartney and Stroup (1983) argued that if tax revenues are used to provide valuable goods, the net income effect of a labor income tax on aggregate labor supply should be zero, and concluded that the tax increase would only have a substitution effect. This conclusion was challenged by a number of authors. One of the most relevant points of contention, shared among others by Bohanon and Van Cott (1986) and Gahvari (1986) was that even if it is true that the additional public goods provision can be interpreted as an increase in equivalent income, this increase is not equivalent to a greater purchasing power in the private goods-leisure space. Note that in our discussion we are assuming that a government program is worthwhile not because the individual obtains benefits that have an income equivalence, but because there is an actual increase in real income. Another

equilibrium unattainable under the original budget constraint C_0 in Figure 1, and condition (5) is reduced to¹¹

$$Nm_G = \frac{(1-R_G)wL}{R_t}.$$

In Figure 2, the benefits of public expenditure shift the budget constraints upward, up to C_3 under the labor income tax, and up to C_4 under the lump-sum tax. Any allocation in the triangular area $\alpha\beta\gamma$ is attainable only with the use of the labor income tax, and unattainable under the lump-sum tax alone. The representative individual *may* exhibit a preference structure under which the use of the labor income tax is necessary to maximize welfare. Such a situation is depicted in Figure 2 by the equilibrium ε_3 . The budget constraint under the labor income tax allows to reach a level of utility u_3 , while the budget constraint under the lump-sum tax would have allowed to reach a lower level of utility u_4 .

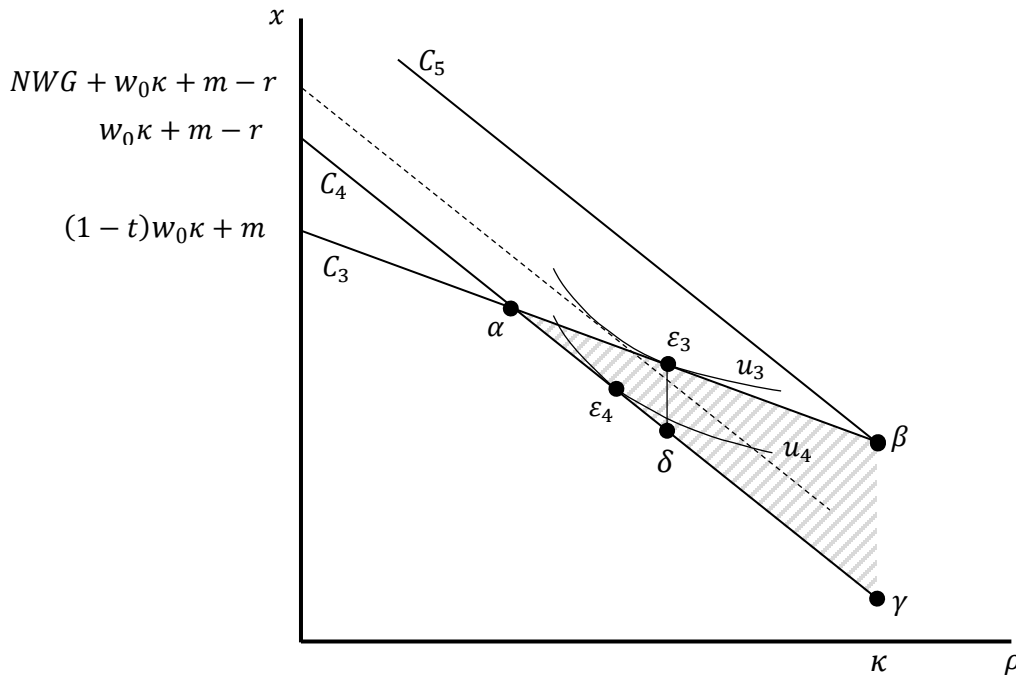
A change in the optimal labor choice under the labor income tax would affect the amount of labor income tax collections and thus also the sustainability of the government program. In Figure 2, the equilibrium at ε_3 represents a situation in which labor supply has been reduced with respect to the labor supply at α (which in this illustration is associated with the same labor supply obtained under ε_1 in Figure 1). This implies that tax collections under the labor income tax are lower than the required amount r . However, a supplementary lump-sum tax, equal to the

difference is that in this paper the income effect is known to be zero only for the last dollar spent; in the absence of preferences for public goods any worthwhile project would by definition increase (total) real income. Consequently, the benefits of public expenditure can possibly be obtained in the form of lump-sum changes in real income or changes in relative prices, thus the optimal combination of public programs can lead to both income and substitution effects.

¹¹ The argument to be presented here is valid whenever public expenditure affects real income and shifts the (after-tax) budget constraint outward, and regardless of whether the public good is enjoyable or not. As long as the positive effects of public expenditure shift the budget constraint outward and move the optimal taxpayer decision under the labor income tax to a point unaffordable under the lump-sum tax, the labor income tax can possibly allow the taxpayer to reach higher levels of utility.

amount of the reduction of tax collections –given by the vertical difference between ε_3 and δ , will ensure that individual tax revenue is equal to r , that the benefits of public goods are equal to m , and thus also that equilibrium ε_3 is both affordable and sustainable.

Figure 2: After-Tax-and-Expenditure Welfare Effects of Lump-Sum and Labor Income Taxes



It is apparent that the combination of labor income and lump-sum taxes can possibly lead to a greater level of utility than the lump-sum tax alone. Using the original wage rate w_0 , the net welfare gain (NWG) of the labor income tax is measured here as the equivalent income difference between the two utility levels. The NWG is positive, which suggests that the labor income tax is not a distortionary tax instrument.

If there are no possible additional welfare gains, then equilibrium ε_3 under the labor income tax would correspond to the first-best solution to the welfare maximization problem. In such a case, (1) and (5) would be some of those first-best conditions, and the price changes

imposed by the labor income tax would have to be interpreted as price corrections, not as distortions.¹² Following Browning and Liu (1998, p.104), “[t]o hold that the income tax is nondistorting [...] must mean that there is no alternative method of financing [public expenditure] that is better (higher utility) for the taxpayers.” Without the use of the labor income tax, the relative price of labor is w_0 , which is the value of the slope of C_0 in Figure 1 and C_4 in Figure 2, both leading to suboptimal solutions; or the slope of C_5 (the original constraint C_0 plus the benefits m), which is unattainable. The price change imposed by the labor income is precisely what allows the economy to obtain the welfare maximizing price vector.

Discussion

This paper shows that, as long as public expenditure affects the ability to afford private goods (shifts the budget constraint), the combined use of labor income and lump-sum taxation can possibly lead to a greater level of utility than the lump-sum tax alone. The longstanding assumption that the lump-sum tax is the only non-distortionary tax instrument is, therefore, inappropriate. It is not correct to presume that the labor income tax is a distortionary tax, or that it necessarily creates a deadweight loss.

The implications of this conclusion are far reaching. Optimal taxation theory is partially based on the assumption that the lump-sum tax is the only non-distortionary tax instrument, and the first best solution to the welfare-maximizing problem is considered to be attainable only with the exclusive use of the lump-sum tax. This paper shows otherwise; the labor income tax can be part of the first best solution to the welfare maximization problem.

¹² At the optimal solution all tax revenue sources should face the same marginal cost of funds, implying that a supplementary lump-sum tax, if necessary, should satisfy a first-best condition analogous to (2.b).

The deadweight loss of any tax different from the lump-sum tax, as defined in mainstream economics, is equal to the equivalent income variation of the substitution effect imposed by it.¹³ For this reason, the substitution effect itself, and by extension any tax-induced change in relative prices, have become synonyms of tax distortions. What this paper shows is that the substitution effect is not an expression of tax distortions.

The association of substitution effects with the concept of tax distortions is very explicit in the literature on the marginal cost of funds. What Ballard and Fullerton (1992) label as the Pigou-Harberger-Browning tradition, considers only compensated elasticities for the measurement of the marginal cost of funds. Compensated elasticities (of labor supply, for instance), are computed after compensating for income variations, and thus consider only substitution effects. This paper is closer to what Ballard and Fullerton (1992) call the Stiglitz-Dasgupta-Atkinson-Stern approach to the measurement of the marginal cost of funds, which considers both the substitution and income effects in the measure of marginal cost of funds.¹⁴ However, Atkinson and Stern (1974) separate the marginal cost of funds into a “revenue effect”, which depends on the income effects of the tax, and a “distortionary effect” related to the substitution effect of the tax. This paper suggests that the last name is misplaced. It is true that the substitution effect results in lower income tax revenue, but it is also true that, combined with a supplementary lump-sum tax, it may allow reaching a higher level of welfare.

¹³ In Figure 1, the substitution effect of the labor income tax on labor supply corresponds to the horizontal distance between ε_1 and the point at which the segmented line is tangent to u_1 .

¹⁴ Note that dividing the numerator and denominator of the right-hand side of (5) by wL , and assuming that w is not affected by G , that expression can easily be shown to be equal to $1/(1 + \epsilon_{L,t})$, where $\epsilon_{L,t}$ is the uncompensated elasticity of aggregate labor supply with respect to the labor income tax rate. Under the Pigou-Harberger-Browning tradition, the uncompensated elasticity is replaced by the compensated elasticity.

Finally, this paper concludes that lump-sum taxation is part of the tax mix that maximizes welfare, but the role of the lump-sum tax and other tax instruments differ from some broadly accepted views. In particular, efficiency and lump-sum taxation are so intertwined in mainstream economics, that other taxes are justified exclusively by the need for redistribution. In this line, Sandmo (1998) states that “[...] the distortionary effects of taxation [...] can only be justified from a welfare economics point of view by their positive effects on the distribution of income.” The conclusion in this paper is very different. The lump-sum tax is clearly preferable when public expenditure has no effect on taxpayers’ budget constraints, and one important case in which that happens is when taxes are collected for redistributive purposes. The implication is that lump-sum taxation can be necessary for redistribution, and that other tax instruments can be necessary for efficiency.

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Appendix

Derivation of (3.a)

Based on (2), and using (1), the first order conditions for the optimal choices of t and G are

$$\begin{aligned} \frac{\partial \Lambda}{\partial t}: \quad & N[(-wl + (1-t)wl_t)u_x - l_t u_\rho] + \lambda Ntwl_t = 0, \\ & \lambda = \frac{wlu_x}{R_t}; \end{aligned} \tag{A.1}$$

$$\begin{aligned} \frac{\partial \Lambda}{\partial G}: \quad & N[(1-t)wl_G u_x - l_G u_\rho + u_G] + \lambda(-1 + R_G) = 0, \\ & \lambda = \frac{Nu_G}{1-R_G}. \end{aligned} \tag{A.2}$$

Condition (3.a) can be obtained by equating the right-hand sides of (A.1) and (A.2) and rearranging.

Derivation of (5)

Based on (2) and considering $l = l(t, w(G), m(G), \kappa(G), G)$ and $\frac{dl}{dG} = l_w w_G + l_m m_G + l_\kappa \kappa_G + l_G$, the first order condition for the optimal choices of t and G are given by (A.1) and

$$\begin{aligned} \frac{\partial \Lambda}{\partial G}: \quad & N\left[\left((1-t)w \frac{dl}{dG} + (1-t)lw_G + m_G\right)u_x + \left(\kappa_G - \frac{dl}{dG}\right)u_\rho + u_G\right] + \lambda(-1 + R_G) = 0 \\ & \lambda(1 - R_G) = N\left[\left((1-t)lw_G + m_G\right)u_x + \kappa_G u_\rho + u_G\right] \end{aligned}$$

Where now $R_G = Nt \left[w_G l + wl \frac{dl}{dG} \right]$.

Using (1),

$$\lambda = \frac{N\left[(1-t)lw_G + m_G + (1-t)w\kappa_G + \frac{u_G}{u_x}\right]u_x}{1-R_G}. \tag{A.3}$$

Equating the right-hand sides of (A.1) and (A.3) and rearranging we obtain

$$N \left[(1-t)lw_G + m_G + (1-t)w\kappa_G + \frac{u_G}{u_x} \right] = \frac{(1-R_G)wL}{R_t}$$

Which is equal to (5).