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Distributionally Sensitive Cost-Benefit Analysis

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Distributionally Sensitive Cost-Benefit Analysis

Abstract

We propose a method for cost-benefit analysis of public policies that identifies potential Pareto improvements when losers from a reform are compensated through income tax changes. Reforms are desirable when they decrease aggregate excess burden in commodity and labor markets. This condition is equivalent to a weighted sum of individual compensating variations, where weights reflect the impacts of the policy reform on individuals' labor incomes, rather than marginal social valuations of transfers to them. We identify cases in which distributional weights are increasing in individual incomes, in spite of inequality concerns.

JEL-Codes: D600, H200, H400, I300.

Keywords: applied welfare economics, weighted surplus, excess burden.

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1 Introduction

Economic policy reforms frequently result in gains to some individuals and losses to others, rendering the overall impact on welfare to be ambiguous. The typical approach to cost-benefit analysis in such cases is to sum measures of individual gains and losses (or “surplus”). If total surplus from the reform is positive, then gainers could in principle compensate losers through lump-sum transfers to accept the reform (Kaldor, 1939), or losers could not afford to compensate gainers to block the reform (Hicks, 1939), and a potential Pareto improvement (PPI) is said to exist. The total surplus approach therefore offers the tantalizing possibility that program evaluation can focus on efficiency implications of reforms, leaving distributional considerations for other branches of government. The total surplus approach to cost-benefit analysis is controversial. The compensation envisaged by the Hicks and Kaldor tests is hypothetical, and need not be paid in practice. Moreover, the Hicks and Kaldor tests assume that compensation would be paid through lump-sum transfers, whereas feasible real-world compensation systems have distortionary costs.¹

These issues have prompted some to advocate a weighted surplus approach, in which individual gains and losses are assigned weights reflecting the presumed social value of transfers to each individual (e.g., Drèze and Stern, 1987; Boadway, 2016). Recently, the US government has proposed in the revised Circular A-4 that distributional weighting should become a standard element of applied cost-benefit analysis, when inequality impacts are important (Hemel, 2023). Hendren (2020) has derived a version of the Hicks-Kaldor tests with distortionary compensation, which applies to differentially small reforms. In the Hendren test, individual surplus is weighted by the marginal efficiency cost of taxes and transfers at each income level.² As Hendren notes, the weights applied to individual surpluses can be interpreted as social welfare weights that would be obtained if the existing income tax system had been chosen by maximizing a social welfare function.³

In this paper, we derive an alternative feasible compensation test that applies to large-scale as well as differential reforms. Many policy changes of interest are discrete in nature. Our approach proposes an exact measure of whether a large policy change constitutes a feasible PPI. In our framework, gainers and losers from policy reforms are compensated through hypothetical changes to an arbitrary non-linear labor income tax in order to keep each individual’s utility fixed at the pre-reform level.

¹There are other concerns with the Hicks-Kaldor tests as well. Scitovsky (1941) showed that the Hicks and Kaldor criteria can lead to preference cycles. Boadway (1974) showed that a positive sum of compensating variations was necessary but not sufficient for a potential Pareto improvement. In this paper, we abstract from these technical considerations by assuming that producer prices are unchanged with the reforms we study.

²The same procedure using weighted compensating variations (CVs) can be used to establish whether the Kaldor test is satisfied, that is, the gainers from the policy change can compensate the losers.

³That is, they are so-called inverse-optimum weights as in Jacobs et al. (2017).

Distributional impacts of policies therefore matter to the extent that they change the cost of redistribution through the income tax system (Weisbach, 2015). When a reform compensated in this way causes government revenue to rise, then under weak conditions the government may redistribute the additional revenues to obtain a hypothetical Pareto improvement. Thus our framework identifies *feasible PPIs*, extending the Hicks–Kaldor approach to incorporate distortionary costs of compensation explicitly.

In our key result (Proposition 1), we show that a compensated public policy reform is a feasible PPI if and only if it reduces the sum of individual excess burdens in all commodity and labor markets.⁴ Excess burden is consumer surplus net of tax payments and is a measure of the efficiency cost of a tax system. This result demonstrates that policies should be evaluated based on an *unweighted* excess burden criterion, irrespective of the distributional objectives of the government. This result complements Harberger (1978), who also advocated evaluating policies using the unweighted sum of excess burdens, though his rationale for ignoring distributional consequences differed from ours. Crucially, our measure of the change in excess burden includes the distortionary effects of the compensation payments themselves. Proposition 1 applies for projects of any size. Restricting attention to small reforms, Corollary 1 shows that the desirability of a reform depends only on its *fiscal externalities*, meaning the effect on government revenue of behavioral responses to the reform and its compensation.

We next examine how our criterion differs from the unweighted total surplus typically calculated by cost-benefit analysts, which ignores the costs of compensating losers and gainers. Proposition 2 shows that a reform is a feasible PPI when a particular *weighted* sum of individual willingness to pay for the reform is positive. The weights in our formula reflect the effects of the policy reform and its hypothetical compensation on labor incomes and so on income tax revenues. Lemma 2 shows how behavioral changes in labor income can be measured. In essence, our approach implies that fiscal externalities should be adjusted downward to reflect the costs of compensation. Our weights do not correspond to the marginal social valuations of income transfers proposed by Drèze and Stern (1987), Boadway (2016) and others to incorporate distributional concerns, nor to the inverse-optimum weights in Hendren (2020). We analyze the differences between these competing welfare criteria in Section 5.

We lay out our framework using the standard model of reforms to consumer taxes and subsidies, as in Laroque (2005) and Kaplow (2006a). This allows us to develop our results using well-known tools of consumer price theory. We show in Proposition 3 how the analysis can be extended to other policy reforms involving changes in prices and quantities that are costly to the government and can make some individuals

⁴Konishi (1995) examines small reforms to commodity tax rates compensated through arbitrary non-linear labor income tax reforms and derives a local version of our Proposition 1.

better off and others worse off. These can include, for example, regulatory changes and public investment expenditures.

1.1 Related literature

Our approach has antecedents in the applied welfare economics literature. In an important early contribution, Hylland and Zeckhauser (1979) studied large policy reforms compensated through a distortionary income tax system, similar to our framework. Under restrictions on preferences, they showed that feasible PPIs can be identified by their impact on unweighted total surplus – a version of the Samuelson rule for evaluating public projects. Laroque (2005) and Kaplow (2006a) independently showed that when preferences for commodities are weakly separable from labor, then reforms to commodity prices compensated through the income tax would leave labor supply unchanged. Therefore, such reforms can be evaluated solely by their impacts on unweighted excess burden in commodity markets.

Our analysis extends this work to the non-separable case where labor supply may change due to the reform. In so doing, we offer a formal treatment of the issues discussed in Kreiner and Verdelin (2012), Kaplow (2020) and Weisbach and Hemel (2022). Our framework generalizes existing results, showing how distributional impacts can be incorporated into cost-benefit analysis in a simple, operational way. Our analysis like Kaplow (2020) evaluates reforms based on their efficiency effects alone, but we also include efficiency effects arising from compensating the inequality impacts of the reform.

As noted above, Hendren (2020) also proposes a method for evaluating policy changes compensated through the income tax.⁵ Our method differs from his in two main ways. For one, we study discrete rather than differential policy changes. For another, our procedure for evaluating policy changes differs from his. Hendren first identifies the willingness of individuals to pay for the policy change and then augments that willingness to pay by the marginal cost of financing transfers to individuals to cover it. The resulting decision criterion is a weighted surplus rule. In Hendren (2020), the weights assigned to each individual income level are assumed to be fixed, independent of the reform being analyzed. Our framework instead endogenizes the marginal cost of compensating each type and so leads to different rules for evaluating reforms.

The compensation payments in our framework, like in Hicks (1939) and Kaldor (1939), may be hypothetical or real. The cost-benefit analysis framework simply identifies the efficiency gains of PPIs. Whether to pay compensation to generate actual Pareto improvements or not is a separate distributive choice. That said,

⁵Likewise, Schulz et al. (2023) develop a cost-benefit test for reforms affecting the distribution of individual wages.

the case for efficiency-enhancing reforms may be less ambiguous when, in Hicks’s words (1939), they are “freed from distributive complications” through the payment of compensation. In practice, reforms are often not accompanied by explicit compensation (Raskolnikov, 2020). An alternative perspective, following Harberger (1978) and Coate (2000), is that the role of cost-benefit analysis is to recommend against the adoption of inefficient policies, and whether to implement efficient reforms or not requires additional judgments about their distributive consequences.

The plan of the paper is as follows. Section 2 presents our model of consumer price changes compensated through reforms to an arbitrary initial income tax system and derives our unweighted excess burden rule. Section 3 characterizes the distortions in labor income that result from feasible hypothetical compensation, and Section 4 shows how our rule can be restated as a weighted sum of individual surplus amounts. Section 5 studies a special case of our model – child care subsidies – and shows how our approach differs from Hendren (2020). Section 6 shows how our results extend to a more general setting in which government policies affect both consumer prices and quantities of public goods that influence consumer welfare in quite general ways. Section 7 concludes. Proofs are provided in the Appendix.

2 Compensated Policy Evaluation

This section develops an efficiency approach to evaluating policy initiatives that can have distributive consequences. Our procedure provides a measure of the net benefit to all individuals and the government of a policy proposal combined with compensating income tax changes that leave all persons at their pre-reform utility levels. The unweighted summation of these compensated net benefits provides an exact measure of the efficiency benefits of the policy-cum-compensation. The approach is closely related to the Kaldor (1939) compensation test which also compensates individuals — albeit hypothetically — using redistributive taxes and transfers to return them to their initial utility level. It differs from the feasible Hicks compensation test proposed by Coate (2000) and Hendren (2020). The Hicks test considers whether individuals can be compensated in the pre-reform situation to make them as well off as in the reform outcome. In other words, are there redistributive policies that are Pareto-superior to the policy reform under consideration?

2.1 The setting

The economy in our example is analogous to the one that was introduced by Mirrlees (1971, 1976) to study optimal income and commodity taxes and that has been widely emulated. There is a continuum of individuals of mass one indexed by j who differ only in a productivity parameter a_j . Production is linear and a_j is also the pre-tax

wage rate. A type- j individual supplies labor ℓ_j and produces output $y_j = a_j \ell_j$, so aggregate output is $\int y_j dj$. When our analysis applies to an individual of a given type, we suppress the subscript j for simplicity. Output is used to provide a vector of n private goods, denoted $\mathbf{x} = (x_1, \dots, x_i, \dots, x_n)$ with fixed producer prices $\mathbf{c} = (c_1, \dots, c_i, \dots, c_n)$. Consumer prices are $\mathbf{p} = (p_1, \dots, p_i, \dots, p_n)$, where $p_i \geq c_i$ for any given good.

The government controls consumer prices through its choice of commodity taxes and subsidies. and it also imposes a non-linear tax on income, $T(y)$, so after-tax income is $y - T(y)$. We assume for simplicity that $T(y)$ is everywhere differentiable. Government revenue requirements are fixed, possibly at zero. Importantly, since our analysis focuses on the possibility of Pareto-improving policy changes, we need not specify government (social) preferences except that they respect the Pareto principle.

Individuals have a common strictly concave utility function of the form $U(\mathbf{x}, \ell) = U(\mathbf{x}, y/a)$.⁶ Given consumer prices \mathbf{p} and the income tax $T(y)$, a type- a individual solves:

$$\max_{\{\mathbf{x}, y\}} U(\mathbf{x}, y/a) \quad \text{s.t.} \quad \mathbf{p}\mathbf{x} = y - T(y) \quad (1)$$

The first-order condition on y is $U_\ell = -\lambda a(1 - T'(y))$, where λ is the Lagrange multiplier. The budget constraint in (1) is non-linear, and we assume that the second-order conditions are satisfied so the first-order conditions define a unique optimum, which we assume to be interior. We assume that income y is increasing in productivity type a .⁷ In analyzing reforms, we can therefore uniquely identify types of individuals by their pre-reform incomes y^0 , and suppress types a from the notation.

It is convenient to linearize the budget constraint in the neighborhood of individual choices to $\mathbf{p} \cdot \mathbf{x} = w\ell + n$ where

$$\begin{aligned} w &= a(1 - T'(y)) \\ n &= yT'(y) - T(y) \end{aligned} \quad (2)$$

are the marginal after-tax wage and virtual income facing the individual who chooses y given income tax $T(\cdot)$. Individual preferences are represented by the indirect utility function

$$V(\mathbf{p}, w, n) = \max_{\{\mathbf{x}, \ell\}} U(\mathbf{x}, \ell) \quad \text{s.t.} \quad \mathbf{p}\mathbf{x} = w\ell + n \quad (3)$$

The solutions to (1) and (3) coincide when (2) holds. The expenditure function

$$E(\mathbf{p}, w, u) = \min \mathbf{p}\mathbf{x} - w\ell \quad \text{s.t.} \quad U(\mathbf{x}, \ell) = u \quad (4)$$

⁶Thus conditional on labor supply all individuals have identical preferences for commodities \mathbf{x} . This ensures that price reforms may be compensated for all types through changes in income taxes alone. For a discussion of compensation with preference heterogeneity, see Hendren (2020), Section 8.3.

⁷This is a standard assumption in the optimal income tax literature. It is a sufficient (second-order) condition for satisfying the the incentive compatibility conditions (Mirrlees, 1971).

is the inverse of V and yields compensated demands for goods and labor income,

$$x_i(\mathbf{p}, w, u) = E_i(\mathbf{p}, w, u) \quad y(p, w, u) = -aE_w(\mathbf{p}, w, u) \quad (5)$$

2.2 Compensated policy reforms

We consider a *compensated reform* in commodity prices from \mathbf{p}^0 to \mathbf{p}^1 together with a reform in the income tax schedule from $T^0(\cdot)$ to $T^1(\cdot)$ that holds each type's utility at its pre-reform level u^0 . To hold utility constant, the individual's linearized tax parameters (w^i, n^i) must change such that

$$u^0 = V(p^0, w^0, n^0) = V(p^1, w^1, n^1) \quad (6)$$

We are interested in the effect of compensated reforms on the government budget constraint. Formally:

Definition 1 *A reform from \mathbf{p}^0 to \mathbf{p}^1 is a feasible potential Pareto improvement (feasible PPI) if government revenue rises in a compensated reform.*

The focus on feasible PPIs reflects the idea that the additional government revenues available after a compensated reform could be transferred back to some individuals to generate an actual Pareto improvement.⁸ We also assume that the initial income tax system $T^0(\cdot)$ is Pareto efficient, since otherwise the definition is satisfied trivially (see Bierbrauer et al., 2023, for a discussion).

How can we characterize feasible PPIs? The compensating virtual income n^1 is implicitly defined in (6). Using the budget constraint $n^i = E(\mathbf{p}^i, w^i, u^0)$, the virtual income change must equal the individual's compensating variation for the change in prices (\mathbf{p}^1, w^1) :

$$n^0 - n^1 = CV \equiv E(\mathbf{p}^0, w^0, u^0) - E(\mathbf{p}^1, w^1, u^0) \quad (7)$$

The CV emerges as the natural way to measure welfare change in our context. We consider whether the gainers can compensate the losers through the income tax system so the reform becomes a Pareto improvement over the pre-reform situation. Our approach is parallel to the Kaldor (1939) approach, although unlike Kaldor we assume that compensation can only be done using the distortionary income tax system.

To evaluate the net benefit of a compensated tax reform, we must take into account how the tax reform affects both individuals and the government. We define the *excess*

⁸As Kaplow (2006a) notes, lump-sum transfers might violate the government budget constraint if recipients' behavior is discontinuous as would occur, for example, if a small transfer induces a discrete reduction in labor supply. Kaplow assumes that behavior is continuous to avoid this possibility.

burden of a tax system in the usual way as the sum of compensating variations for removing all taxes, net of the revenue that they generate.⁹ Formally:

Definition 2 *The excess burden of a type- a individual from a linear tax system (\mathbf{p}^i, w^i) , $i = 0, 1$ is*

$$eb^i = E(\mathbf{p}^i, w^i, u^0) - E(\mathbf{c}, a, u^0) - (\mathbf{p}^i - \mathbf{c})\mathbf{x}^i - (a - w^i)\ell^i \quad (8)$$

Aggregate excess burden is the unweighted sum over all individuals, $EB^i = \int eb^i dF^i(y)$. Using (7)–(8) and the government budget constraint $G^i = \int [T^i + (\mathbf{p}^i - \mathbf{c}) \cdot \mathbf{x}^i] dF^i$, we obtain our main characterization of feasible PPIs:

Proposition 1 *The change in government revenue in a compensated reform equals minus the change in aggregate excess burden:*

$$G^1 - G^0 = -(EB^1 - EB^0) \quad (9)$$

Thus a reform is a feasible PPI if and only if it reduces excess burden.

This is a simple yet remarkable result. The proposition states that winners and losers from the reform can be compensated through the income tax if and only if the combined reform package would reduce excess burden. The result does not rely on an assumption that income taxes are themselves linear in income. (Indeed, the result would not be true if attention were confined to linear tax reforms.) Observe moreover that the aggregate excess burden measure in (9) is not weighted by any measure of inequality in incomes or by social preferences for inequality. The proposition implies that the conventional tools of applied welfare analysis due to Harberger (1978) and others can be used to evaluate the desirability of policy reforms in a way that is sensitive to distributional concerns.

Proposition 1 applies whether projects are large or small. Hendren (2020) and Schulz et al. (2022) have derived cost-benefit rules for compensated small projects. Differentiating (8) yields a simple alternative expression for the change in excess burden and hence for evaluating small compensated policy reforms:

Corollary 1 *A small reform $d\mathbf{p}$ is a feasible PPI if and only if the aggregate fiscal externality from behavioral responses to the reform is positive:*

$$dG = -dEB = \int [T'(y)dy + (\mathbf{p} - \mathbf{c}) \cdot d\mathbf{x}] dF(y) > 0 \quad (10)$$

⁹Note that our definition of excess burden deducts revenues of the linearized income tax, which may differ from the revenues of the actual tax T . While excess burden is defined as a difference from a hypothetical no-tax benchmark allocation, our results below depend on the change in excess burden, so that the specific benchmark allocation is irrelevant. Our approach to measuring excess burden is equivalent to that used by Harberger (1978). His Figure 1(b) depicts the net benefit of an excise tax on a single good. The result is the standard deadweight loss triangle.

In the large project case, the change in government revenue is minus the change in excess burden. In the differential case, consumers' willingness to pay for the reform offsets its mechanical effect on government revenue, leaving only the fiscal externality, or the change in government revenues from behavioral responses. The equivalence between marginal excess burden and marginal fiscal externalities is a common result in the cost-benefit analysis literature (e.g. Harberger, 1971). In (10), however, the behavioral responses ($dy, d\mathbf{x}$) also incorporate the distributional impacts of the reform through the efficiency costs of the compensatory changes to income taxes, which are captured in the general equilibrium behavioral functions $y = -aE_w(\mathbf{p}, w(\mathbf{p}, u^0), u^0)$ and $x_i = E_i(\mathbf{p}, w(\mathbf{p}, u^0), u^0)$.

In some contexts, it is more convenient to calculate the change in production quantities induced by a reform, rather than the change in government revenue. The two concepts are closely related. Given Walras's law,¹⁰ government tax revenue equals aggregate production less private consumption valued at producer prices, i.e.

$$G^i = \int (y^i - \mathbf{c} \cdot \mathbf{x}^i) dF^i$$

Thus the change in revenue from the reform equals the change in net production. Invoking Proposition 1, we have:

Corollary 2 *The change in excess burden from a reform equals the change in aggregate net production valued at producer prices:*

$$-(EB^1 - EB^0) = (Y^1 - Y^0) - \mathbf{c}(\mathbf{X}^1 - \mathbf{X}^0) \quad (11)$$

If a policy reduces aggregate excess burden, it will also increase net production. There will be resources left over after all persons have been compensated, and those resources can be used to make some or all persons better off than in the initial situation. In that sense, the policy has improved efficiency.

2.3 Relation to the literature

Proposition 1 is related to a number of earlier results that also analyze income-tax compensated policy changes. Hylland and Zeckhauser (1979) considered the evaluation of government expenditure programs whose total monetary benefits were fixed, but whose relative benefits to different individuals were related to incomes. In such a setting, the introduction of an expenditure program could be accompanied by a reform of the income tax such that all persons achieved the same utility level. In these circumstances, the program should be evaluated on efficiency grounds using net

¹⁰This follows from substituting the individual budget constraints $\mathbf{p} \cdot \mathbf{x} = y - T$ into the government budget constraint $G = \int (T + (\mathbf{p} - \mathbf{c}) \cdot \mathbf{x}) dF$.

monetary benefits without distributional weights. They provided no discussion of how monetary benefits and costs should be measured or the properties of compensating income tax reforms.

In a commodity tax reform framework similar to ours, Laroque (2005) and Kaplow (2006a) assumed that labor was weakly separable from commodities in preferences, i.e.

$$U(\mathbf{x}, \ell) = H(\phi(\mathbf{x}), \ell) \quad (12)$$

for some increasing functions $\phi(\cdot)$ and $H(\cdot, \ell)$. They independently showed that reforms to eliminate distortionary commodity taxes can in the separable case always be compensated through the income tax.¹¹ Extending this logic, Kaplow (2002, 2006b, 2010, 2020) showed that separability implies arbitrary reforms should be evaluated by their impact on unweighted total surplus.¹² The Laroque–Kaplow results emerge as a special case in our setting:

Corollary 3 *Assume that preferences take the weakly separable form (12). Then a compensated reform in commodity prices:*

- (i) *leaves reported incomes y^0 unchanged; and*
- (ii) *is a feasible PPI if and only if it decreases unweighted excess burdens in commodity markets, i.e.*

$$G^1 - G^0 = -\mathbf{c} \cdot (\mathbf{X}^1 - \mathbf{X}^0) > 0$$

The proof of Corollary 3, originally due to Laroque (2005), is instructive and so included here. Let $v(\mathbf{p}, m) = \max\{\phi(\mathbf{x}) : \mathbf{p}\mathbf{x} \leq m\}$ denote the agent’s indirect utility from commodities, given prices and after-tax income m . Because preferences are separable, this function is independent of labor supply. In a compensated reform, $T^1(\cdot)$ may be chosen so that

$$v(\mathbf{p}^1, y - T^1(y)) = v(\mathbf{p}^0, y - T^0(y)) \quad \text{for all } y. \quad (13)$$

Faced with the post-reform prices and income tax system, an agent with productivity type a chooses y to maximize

$$H(v(\mathbf{p}^1, y - T^1(y)), y/a) = H(v(\mathbf{p}^0, y - T^0(y)), y/a) \quad (14)$$

Since the agent’s utility from any reported income y is unchanged in the compensated reform, it is optimal to choose $y^1(a) = y^0(a)$, i.e. labor income is unchanged.

¹¹Hellwig (2009) and Boadway and Cuff (2022) establish conditions under which reforms towards uniform taxation can be compensated through reforms to a linear or piecewise linear income tax.

¹²This generalized the famous result of Atkinson and Stiglitz (1976) that an optimal non-linear income tax system need not be supplemented by any commodity taxes or subsidies in the separable case.

So potential labor market effects of the reform can be ignored and, applying Proposition 1, such a reform is feasible if and only if the reform decreases excess burden in commodity markets.

In our analysis below, we examine in detail the non-separable case where labor supply may change, and show how fiscal externalities from the policy reform and its compensation can also be incorporated into the analysis.¹³ In so doing, we offer a formal treatment of the issues discussed in Kaplow (2020) and Weisbach and Hemel (2022).

3 Compensation and labor distortions

Proposition 1 establishes very generally that feasible compensated price reforms can be identified by calculating the unweighted total surplus they generate net of their fiscal costs. But total surplus includes not only the “partial equilibrium” surplus accruing as a direct consequence of the policy reforms, but also the distortionary impacts of compensation through the income tax system. Labor market distortions resulting from the reform will not in general be proportional at various income levels, and so our cost-benefit criterion (9) is not an unweighted sum of partial equilibrium surpluses in general. In the next sections, we show how our unweighted excess burdens criterion for a feasible PPI can be expressed as a particular weighted sum of partial equilibrium surpluses, where the weights reflect the efficiency cost of compensation through the hypothetical income tax reform.

To show how labor market distortions should be incorporated into cost-benefit analysis, we first characterize the distribution of post-reform incomes y^1 and of marginal tax rates $T^{1'}(y^1)$ that emerge from the compensated reform. The compensation condition (6) must hold at the income levels reported by each type of individual. In the appendix, we differentiate (6) with respect to the pre-reform income to prove this useful result:

Lemma 1 *Assume that $U(\mathbf{x}, \ell)$ is twice continuously differentiable. At every compensated reform policy $(\mathbf{p}^1, T^1(\cdot))$ and income distribution $F^1(\cdot)$,*

$$(1 - T^{1'}(y^1))y^1 = \frac{V_n(\mathbf{p}^0, w^0, n^0)}{V_n(\mathbf{p}^1, w^1, n^1)}(1 - T^{0'}(y^0))y^0 \quad (15)$$

for almost all y^0 .

¹³Konishi (1995) also studied a differential tax reform in a heterogeneous household economy with non-linear income taxation. Starting with a uniform commodity tax on all goods, he derived a result analogous to Proposition 1, though it only applies to differential changes in a single commodity tax.

Equation (15), which applies to large as well as small reforms, is a joint condition on post-reform incomes and marginal tax rates that must be satisfied in a compensated reform. In the separable case of Corollary 3, income is unchanged, and Lemma 1 leads to an explicit formula for the compensatory tax changes:

$$1 - T^{1'}(y) = \frac{v_n(\mathbf{p}^0, n^0)}{v_n(\mathbf{p}^1, n^1)}(1 - T^{0'}(y))$$

Marginal take-home rates are scaled to compensate for the change in marginal utility of income due to the reform (see Boadway and Cuff, 2022).

To get explicit solutions for the labor income distortion in the general case, it is more convenient to work in the dual price space, characterizing how marginal after-tax wages w change with the reform. To do so, we use the expenditure function $E(\mathbf{p}, w, u)$ defined in (4) to write (15) as

$$\frac{w^1 E_w(\mathbf{p}^1, w^1, u^0)}{E_u(\mathbf{p}^1, w^1, u^0)} = \frac{w^0 E_w(\mathbf{p}^0, w^0, u^0)}{E_u(\mathbf{p}^0, w^0, u^0)} \quad (16)$$

This defines the compensatory marginal after-tax rate, say $w^1 = w(\mathbf{p}^1, u^0)$, that must be paid in the post-reform equilibrium to the agent-type that receives utility u^0 in the status quo. (We suppress the dependence of the function on the initial prices (\mathbf{p}^0, w^0) for notational convenience.) The resulting reported income¹⁴ is then

$$y^*(\mathbf{p}^1, u^0) = -a E_w(\mathbf{p}^1, w(\mathbf{p}^1, u^0), u^0) \quad (17)$$

Equation (17) characterizes the distortion in reported incomes that results from the compensated policy reform, which in turn determines the change in surplus in labor markets which forms part of our general cost-benefit rule of Proposition 1. But (17) depends on derivatives of the consumer expenditure function on the linearized budget constraint, which is not generally known to the cost-benefit analyst. It is therefore preferable to restate our cost-benefit rule using quantities that are observed or estimable for the researcher. To do so, we now focus on “small” policy reforms $d\mathbf{p} = \mathbf{p}^1 - \mathbf{p}^0$ and calculate differential changes to (6) and (15). Later, we discuss how the effects of “large” policy reforms can be approximated with this approach.

The compensated commodity demand and labor supply functions on the linearized budget constraints are given by (5). We define compensated wage elasticities of demand and supply in the usual way (Saez, 2001):

$$\varepsilon_{iw} = \frac{w E_{iw}}{E_i} \quad \text{and} \quad \varepsilon_{\ell w} = \frac{w E_{w\ell}}{E_w}$$

¹⁴This function generalizes the wage-compensated labor supply function analyzed in Besley and Jewitt (1995) for the case of linear income taxes.

Uncompensated demand and supply functions are $\hat{x}_i(\mathbf{p}, w, n) = E_i(\mathbf{p}, w, V(\mathbf{p}, w, n))$, $i = 1, \dots, n$, and $\hat{\ell}(\mathbf{p}, w, n) = -E_w(\mathbf{p}, w, V(\mathbf{p}, w, n))$, so that the Slutsky decomposition is

$$\hat{\varepsilon}_{iw} = \varepsilon_{iw} + \eta_i \quad \text{and} \quad \hat{\varepsilon}_{\ell w} = \varepsilon_{\ell w} + \eta_\ell \quad (18)$$

where $\hat{\varepsilon}_{iw}$ and $\hat{\varepsilon}_{\ell w}$ are the uncompensated wage elasticities, and the income effect terms are

$$\eta_i = w\ell \frac{\hat{x}_{in}}{x_i} \quad \text{and} \quad \eta_\ell = w\hat{\ell}_n.$$

With this notation in place, we show in the appendix that differentiating (16) with respect to \mathbf{p} yields:

Lemma 2 *The change in labor income from a small compensated price reform is*

$$dy = - \sum_i [\varepsilon_{iw} - \varepsilon_{\ell w} \omega_i] \frac{x_i dp_i}{1 - T'} \quad (19)$$

where

$$\omega_i = \frac{\ell}{x_i} \frac{\partial w(\mathbf{p}, u^0)}{\partial p_i} = \frac{\hat{\varepsilon}_{iw}}{1 + \hat{\varepsilon}_{\ell w}} \quad (20)$$

is the required compensation in labor income, per dollar of consumer surplus in commodity market i .

Lemma 2 characterizes the production effects resulting from compensated reforms in terms of estimable compensated and uncompensated elasticities. It shows the potential tradeoffs between the direct effects of taxing or subsidizing commodities complementary or substitutable with labor, and the offsetting effects resulting from the necessary income tax compensation. The effect on output resulting from each component of the reform dp_i is proportional to the marginal surplus $-x_i dp_i$ that it creates, and to the magnitude of the resulting substitution effects in demands, represented by the elasticity expression in brackets in (19). The first term in brackets is the direct effect of the policy reform on labor supply, which is proportional to the compensated wage elasticity of demand ε_{iw} . Thus a reduction $-dp_i > 0$ in the price of a net complement for labor ($\varepsilon_{iw} > 0$) reduces labor supply. At the same time, the reform includes a compensatory reduction in the agent's marginal take-home share $1 - T'$, the effect of which is measured by the second term in brackets. This effect through the income tax channel is proportional to the magnitude of the change in the marginal take-home share (which depends on the uncompensated wage elasticities of x_i and ℓ) and to the compensated wage elasticity of labor supply $\varepsilon_{\ell w}$.

On balance, the net effect of such interventions could be positive or negative. Figure 1 depicts the labor market response to a subsidy on a product that is a net complement with labor, for two possible values of the wage elasticity of labor

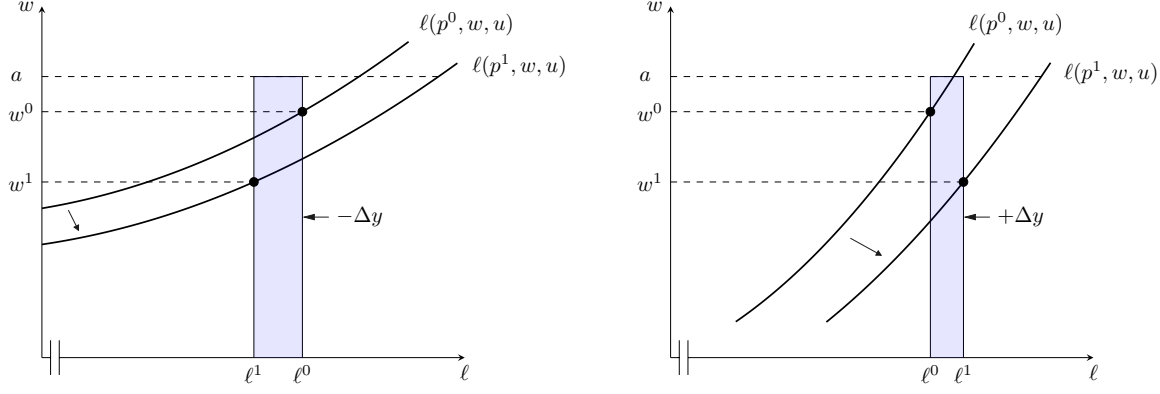


Figure 1: Change in excess burden in the labor market

Note: The figure depicts the labor market response to a subsidy on a product that is a net complement with labor. In the left panel, the labor supply elasticity is high and the excess burden is positive; in the right panel, the labor supply elasticity is small and the excess burden is negative.

supply $\varepsilon_{\ell w}$. The subsidy shifts the labor supply curve outward from $\ell(\mathbf{p}^0, w, u)$ to $\ell(\mathbf{p}^1, w, u)$. The required compensation through the income tax induces a movement along $\ell(\mathbf{p}^1, w, u)$ from w^0 to w^1 . Proposition 1 indicates that the resulting change in excess burden due to labor supply responses equals the change in income Δy , depicted as the shaded regions in Figure 1. In the left panel, $\varepsilon_{\ell w}$ is high and the excess burden is positive; in the right panel, $\varepsilon_{\ell w}$ is small and the excess burden is negative.

To see more clearly the contribution of the elasticity terms to labor market effects, we use the Slutsky decomposition (18) to write (19) as

$$dy = - \sum_i \left[\frac{\varepsilon_{iw}(1 + \eta_\ell)}{1 + \hat{\varepsilon}_{\ell w}} - \frac{\varepsilon_{\ell w} \eta_i}{1 + \hat{\varepsilon}_{\ell w}} \right] \frac{x_i dp_i}{1 - T'}$$

Highly income elastic commodities (those with η_i large) require larger compensatory changes in the income tax schedule for high-income taxpayers, magnifying the distortionary effects of compensation. Highly income elastic commodities should be taxed more (or subsidized less), and so receive a larger weight in our cost-benefit criterion (9).

4 A weighted surplus rule

In the separable case, Corollary 3 shows that the cost-benefit analyst should focus on efficiency effects on commodity markets affected by the price reform, i.e. unweighted changes in excess burdens in commodity markets. There is no need to account for

changes in excess burdens in labor markets from income tax reforms. However, Corollary 3 depends crucially on the assumption that labor is separable in consumer preferences, so that compensated reforms induce no changes in labor supply, and therefore no changes in excess burdens on labor markets.

To evaluate the desirability of a reform in the general case, Proposition 1 and Corollary 1 show that the labor distortions induced by the reform and its compensation must be added to its direct effects on commodity markets. As we show next, when preferences are non-separable, the criterion of Corollary 1 is equivalent to a particular *weighted* sum of individual compensating variations resulting from the reform to commodity prices. We call these “welfare weights,” although it is understood these represent the fiscal externality effects of the reform, rather than normative values assigned to individual surpluses.

Proposition 2 *Consider a small reform $d\mathbf{p}$ that induces consumer surplus $ds_j = -x_j dp_j$ for an individual with status quo consumption level x_j in commodity markets $j = 1, \dots, n$. The reform is feasible PPI if and only if*

$$dG = \sum_j \int \left[\frac{T'}{1 - T'} (\varepsilon_{jw} - \varepsilon_{\ell w} \omega_j) - \sum_i \frac{p_i - c_i}{p_i} (\varepsilon_{ji} - \varepsilon_{\ell i} \omega_j) \right] (-x_j dp_j) dF > 0 \quad (21)$$

Proposition 2 is a “sufficient statistics” formula that expresses the fiscal externalities as a weighted sum of each individual’s partial equilibrium surplus from the reform, $-\sum x_j dp_j$, where the welfare weights, the terms in square brackets in (21), depend on estimable compensated and uncompensated elasticities.

The welfare weights are complicated in general, because of the interplay of pre-existing distortions $p_j - c_j$ and substitution effects in commodity markets.¹⁵ The weighted surplus rule becomes clearer if we assume that initial commodity tax rates are all equal, $p_i = (1 + \tau)c_i$. In this case, the commodity tax system could be replaced by a scaling of the income tax system to $y - \tilde{T}(y) = (y - T(y))/(1 + \tau)$. We can without loss of generality set $\tau = 0$, and we can evaluate the reform solely by its impact on grossed-up income tax revenues.¹⁶

Corollary 4 *If there are no commodity taxes or subsidies imposed in the status quo allocation, then the reform is a feasible PPI if and only if it satisfies the weighted surplus rule*

$$dG = \sum_j \int \underbrace{\frac{T'(y)}{1 - T'(y)}}_{\text{tax factor}} \underbrace{\left(\varepsilon_{jw} - \varepsilon_{\ell w} \frac{\hat{\varepsilon}_{jw}}{1 + \hat{\varepsilon}_{\ell w}} \right)}_{\text{elasticity factor}} \underbrace{(-x_j dp_j)}_{\text{marginal surplus}} dF > 0 \quad (22)$$

¹⁵For approaches to characterizing changes in excess burden in commodity markets from arbitrary reforms under linear taxes, see Konishi (1995) and Smart (2002).

¹⁶A similar result was proven in Konishi (1995).

The weighted surplus rule captures the impact of a small reform and its compensation on labor incomes through the elasticity factor, which in turn affects the government budget through the tax factor. These two terms together weight the aggregate partial equilibrium surplus of the reform. The elasticity factor has two components. The first term, ε_{jw} , represents the direct fiscal externality of the policy on income tax revenues. The second term, proportional to $\varepsilon_{\ell w}$, is the fiscal externality resulting from compensation itself, which is absent from the conventional approach to measuring fiscal externalities (e.g. Kleven, 2021). Incorporating this Hicks-Harberger effect into cost-benefit analysis offsets a portion of the fiscal externalities of labor-enhancing reforms, as we show in the application below.

The formula in (21) is valid beginning from any post-reform policy \mathbf{p}^1 . In principle, the effects of a discrete policy change $\Delta \mathbf{p}$ may therefore be estimated by the first-order approximation $\Delta G \approx \sum \partial G / \partial p_i \Delta p_i$. In practice, since little is known empirically about the derivatives of the relevant elasticities, this will amount to a local approximation at the status quo point \mathbf{p}^0 .

Observe that distributional weights in (22) do not correspond to the marginal social valuation of transfers to each income group. Instead of marginal social valuations, weights reflect the fiscal externalities of the reform and its compensation, as conjectured by Weisbach (2015).

5 Comparison to Hendren (2020)

Hendren (2020) has also proposed a method for aggregating individual willingness to pay that, like ours, is based on notional compensation through the income tax system, but which reaches different conclusions about implied welfare weights. To facilitate comparisons, we now consider a simple example that preserves the essential details of both methods while stripping away some of the complications.

The consumer supplies labor and consumes a bundle (x, z) where z is a numéraire and x a commodity that may be taxed or subsidized. To fix ideas, it may be helpful to think of x as the demand of a working parent for child care services, in which case x and ℓ are net complements. (The case of substitutes is symmetric.) The producer prices of x and z are fixed at one. Preferences are quasi-linear in z , so that on the linearized budget constraint the agent solves

$$\max z - C(\ell, x) \quad \text{s.t.} \quad z = w\ell - px$$

where C is the utility cost of labor supply given child care purchases. Given quasi-linearity, there are no income effects on the optimal demand for child care $x(p, w)$ or on labor income $y(p, w) = a\ell(p, w)$.

For a marginal reform dp in the price of child care beginning from the undistorted

producer price $p = 1$, Corollary 4 indicates that the reform is a potential Pareto improvement if and only if its behavioral effect on income tax revenues is positive, or

$$dG = \int \frac{T'}{1 - T'} \frac{\varepsilon_{xw}}{1 + \varepsilon_{\ell w}} (-x dp) dF > 0 \quad (23)$$

This expression offers a straightforward method for aggregating taxpayers' marginal willingness to pay $-x dp$ for the reform. The implied welfare weights are increasing in the degree of complementarity between child care and labor, as measured by ε_{xw} , which governs the conventional fiscal externality of taxing a complement for labor. They are decreasing in the labor distortions created by compensation payments, as measured by the elasticity of taxable income $\varepsilon_{\ell w}$, which governs the additional fiscal externalities resulting from compensation. Moreover, the weights are increasing in marginal income tax rates T' , which affect the magnitude of fiscal externality resulting from a given change in labor income. If marginal tax rates are increasing (and the elasticity expression non-decreasing) in income, we may conclude that welfare weights are larger for taxpayers with *higher* incomes.

Under Hendren's method, as described in Section 1 above, taxpayers' marginal surplus $-x dp$ is multiplied by weights $\omega(y)$ before being aggregated to $\int \omega(-x dp) dF$ and compared to the marginal fiscal cost of the reform, net of its direct behavioral effects on tax revenue. A reform is desirable if

$$d\Omega = \int \omega(y) (-x dp) dF - \text{fiscal cost} > 0$$

In the case of our child care tax/subsidy reform, this net fiscal cost is minus the associated marginal revenues, or¹⁷

$$\text{fiscal cost} = \int \left(1 - \frac{T'}{1 - T'} \varepsilon_{xw} \right) (-x dp) dF \quad (24)$$

Hendren proposes that the weights $\omega(y)$ should equal the net fiscal of cost of transferring \$1 to a taxpayer of income y through an income tax reform, including the fiscal externalities of the compensating tax reform,¹⁸ or $\omega(y) = 1 + FE(y)$. The welfare criterion is therefore that the reform is welfare-improving if

$$d\Omega = \int \left(\frac{T'(y)}{1 - T'(y)} \varepsilon_{xw} + FE(y) \right) (-x dp) dF > 0 \quad (25)$$

Since there are no income effects or participation effects on labor income, the income tax reform problem is the tractable one first analyzed by Diamond (1998).

¹⁷See Hendren's Appendix G. The fiscal cost is $-x dp - T' dy$ where dy is the effect of the subsidy on labor income. By Slutsky symmetry, $dy = -(a/w) \varepsilon_{xw} x dp$. Substituting yields (24).

¹⁸This net fiscal cost is calculated as the Gateaux differential of revenue for a tax-reducing local reform centred on income y (see Bierbrauer et al., 2023).

The form of the fiscal externality in this case is well known (see e.g. Hendren, 2020, equation (4)),

$$FE(y) = \frac{T'}{1 - T'} \varepsilon_{\ell w} \left(1 + \frac{yf'(y)}{f(y)} \right)$$

Hendren (2020) shows that $1 + yf'/f$ is sharply decreasing in y for the US income distribution up to the 95th percentile, becoming negative above the 60th percentile. As a result, the welfare weights in (25) may be decreasing in income. In contrast, our criterion in (23) aggregates surplus using weights that exclude this distribution term. Our weights are therefore increasing in marginal tax rates and, for tax systems with marginal rate progressivity, increasing in income.

How could such similar approaches to the Hicks-Kaldor compensation principle yield such different conclusions? The answer lies in the weights $\omega(y)$ assumed in Hendren (2020). These are the fiscal cost of compensation through an income tax reform in the neighborhood of income y , holding the rest of the income tax schedule constant. In contrast, the weights in our criterion reflect the fiscal cost of compensation at each income level, given that all compensation occurs simultaneously. Consequently, the fiscal externalities of compensation are lower in our approach than Hendren's, and the correlation of welfare weights with income changes as well.

The differences in our methods are particularly stark when there is no complementarity, so that $\varepsilon_{xw} = 0$. In that case, our method implies $dG = 0$, since a small tax or subsidy has no first-order effect on excess burden in any market if there is no complementarity. The Hendren criterion is nevertheless non-zero, because the resulting transfers to high- and low-income individuals are assigned value, relative to what could be achieved through income tax reforms.

As a cost-benefit analysis of child care subsidies, the model presented in this section is evidently rather stylized. The general framework of Corollary 4 includes income effects on child care demand and labor supply that are absent from the example illustrated here. If child care expenditures are increasing in income, then a disproportionate share of subsidy payments would accrue to high-income families. This strengthens the role of inequality in cost-benefit analysis. Compensating these effects through income tax reforms would offset a portion of the positive fiscal externalities of the subsidy.

6 General policy reforms

The model of Section 2 considered cost-benefit rules for cases where the government sets consumer prices of certain commodities through taxes and subsidies, which is a familiar setting analyzed in much of the previous literature. In fact, our model and our conclusions about cost-benefit rules apply to a much more wider class of

policy reforms, encompassing a variety of public goods and regulatory rules as well as corrective taxes for externalities.¹⁹ In this section, we sketch a model of general policy reforms and show how our conclusions apply in this setting.

As before, the planner chooses a policy vector \mathbf{p} and a tax function T , and we consider compensated reforms from $(\mathbf{p}^0, T^0(\cdot))$ to $(\mathbf{p}^1, T^1(\cdot))$. Individuals of productivity type a choose labor income y and a vector of other choices \mathbf{x} to

$$\max_{(\mathbf{x}, y)} U(\mathbf{x}, \mathbf{p}, y/a) \quad \text{s.t.} \quad h(\mathbf{p}, \mathbf{x}) \leq y - T(y) \quad (26)$$

Here, the cost to the household of choosing \mathbf{x} when the policy vector is \mathbf{p} is $h(\mathbf{p}, \mathbf{x})$, a twice-differentiable, quasi-convex function. Likewise, let the fiscal cost²⁰ to the government of policy \mathbf{p} be $f(\mathbf{p}, \mathbf{x})$ when the agent chooses \mathbf{x} . The net fiscal contribution of an individual choosing (\mathbf{x}, y) is then

$$g = T(y) - f(\mathbf{p}, \mathbf{x}) \quad (27)$$

This framework incorporates in a very general way consumption public goods p_k for which $\partial U / \partial p_k \neq 0$, as well as public goods which change the marginal cost of private consumption, $\partial^2 h / \partial x_i \partial p_k \neq 0$. Although we use the term “public good” to describe quantities chosen directly through government policy, our framework can accommodate both publicly-provided private goods, and pure public goods for all individuals consume the same quantity, $x_j = \hat{x}$ for all j . This framework evidently also subsumes the commodity tax-and-subsidy model of Sections 2 and 3 as a special case, with $h(\mathbf{p}, \mathbf{x}) = \mathbf{p} \cdot \mathbf{x}$ as household expenditures on commodities, and $f(\mathbf{p}, \mathbf{x}) = (\mathbf{c} - \mathbf{p}) \cdot \mathbf{x}$ as the fiscal cost of subsidies to consumer purchases.

Let

$$e(\mathbf{p}, \ell, u) = \min_{\mathbf{x}} \{h(\mathbf{p}, \mathbf{x}) : U(\mathbf{x}, \mathbf{p}, \ell) \geq u\} \quad (28)$$

be minimum cost of \mathbf{x} , given ℓ . Once again, we analyze individuals’ choices on the linearized after-tax budget constraint using the value function

$$E(\mathbf{p}, w, u) = \min_{\ell} \{e(\mathbf{p}, \ell, u) - w\ell\} \quad (29)$$

Obviously, (\mathbf{x}, y) attains the maximum in (26) at $u = U(\mathbf{x}, \mathbf{p}, \ell)$ if and only if $\ell = y/a$ attains the minimum of E for (w, n) , so that $h - w\ell = n \iff h = y - T(y)$.

As before, a compensated reform entails choice of income tax parameters (w^1, n^1) for each agent type that satisfy the compensation condition (6). We may define the excess burden of policy (\mathbf{p}^i, w^i) as

$$eb^i = E(\mathbf{p}^i, w^i, u^0) - (a - w^i)\ell(\mathbf{p}^i, w^i, u^0) + f^i \quad (30)$$

¹⁹Environmental taxes and “sin” taxes on unhealthy commodities are often criticized for their regressive impacts (Allcott et al., 2019; Conlon et al., 2022).

²⁰The fiscal cost of some regulatory policies \mathbf{p} might in principle be zero.

which corresponds to our definition of excess burden for the consumer price model, with the fiscal cost of the policy f^i replacing (minus) commodity tax revenues.

Proposition 1 holds for general policy reforms, given the measure of excess burden in (30). That is, a compensated reform is feasible if and only if $G^1 - G^0 = -(EB^1 - EB^0) > 0$. While this is an unweighted total surplus criterion, it once again includes the change in surplus in the labor market – which in turn depends on the way in which labor supply is distorted as a result of compensation. The compensated after-tax wage is again a function $w(\mathbf{p}^i, u^0)$ defined in (16). Incorporating general equilibrium responses, the fiscal cost of a policy \mathbf{p} is a function $f^*(\mathbf{p}^i, u^0) = f(\mathbf{p}^i, \mathbf{x}(\mathbf{p}^i, w(\mathbf{p}^i, u^0)), u^0)$.

We may analyze the impact of small reforms using Lemma 1, which is unchanged in this more general setting. Define

$$q_k = -\frac{\partial E(\mathbf{p}, w, u^0)}{\partial p_k} \quad (31)$$

as the individual's marginal willingness to pay for policy p_k .²¹ For marginal policy reforms $d\mathbf{p} = (dp_1, \dots, dp_K)$, the cost-benefit test criterion can be obtained from (9) by differentiating (30) to obtain:

Proposition 3 *A small reform $d\mathbf{p}$ is a feasible PPI if and only if it satisfies the generalized Samuelson rule*

$$dG = \sum_k \int \left[(q_k - f_k^*) + T'(y) \frac{\partial y^*(\mathbf{p}, u^0)}{\partial p_k} \right] dp_k dF > 0 \quad (32)$$

This is a generalized Samuelson rule for evaluating public policies. The $q_k - f_k^*$ term in (32) is each individual's marginal valuation of the public policy p_k , net of its fiscal cost. Samuelson (1954) identified Pareto-efficient policies in the first-best case as those for which $\int (q_k - f_k^*) dF = 0$. In (32), the usual Samuelson condition is augmented by an additional term reflecting the effect of the policy on income tax revenues, $\int T' dy dF$, where dy is characterized in Lemma 2.²² A compensated policy reform is feasible when the sum of the two expressions is positive. The cost-benefit test criterion (32) may be applied to conduct distributionally sensitive cost-benefit analysis of any policy intervention for which heterogeneous net benefits of the policy have been estimated, and the effects of the policy on income tax revenues is known.

²¹Lemma 2 holds without change in our more general model, where elasticities are of the shadow prices q_i rather than of demand quantities x_i as in the restricted model of consumer price reforms presented in Section 3. Thus the model tells us that the marginal social value of public policies equals the sum of individual valuations, plus a term representing the policies' impact on labor incomes.

²²Proposition 2 of Kreiner and Verdelin (2012) parallels Proposition 3 closely, but characterizes the behavioral change in income dy by the derivatives of marginal rates of substitution, rather than the uncompensated elasticities of Lemma 2.

When labor supply is separable from policies in preferences, i.e.

$$e(\mathbf{p}, \ell, u) = \hat{e}(\mathbf{p}, \psi(\ell, u)) \quad (33)$$

then we may show, analogous to Corollary 3, that labor supply is unchanged in compensated reforms.²³ The cost-benefit test criterion in (32) then reduces to the Samuelson criterion, i.e. the unweighted total marginal surplus

$$\sum_k \int (q_k - f_k^*) dp_k dF$$

In the separable case, an unweighted total surplus rule should be used to evaluate public goods reforms, independent of distributional concerns.²⁴

Our model and main conclusions therefore apply to project evaluation in a general setting in which government policies affect individuals' budgets and utility functions in arbitrary ways. Our model of government policies as bundles of prices and quantities of consumer products complements others' approaches to distributionally sensitive cost-benefit analysis. Hendren (2020) offers a different method of evaluating reforms that lead to changes in lump-sum exogenous income. In holding the distribution of pre-tax productivity parameters a_j fixed, production in our model is restricted to be additive in individual labor supplies. The effect of reforms and their compensation on pre-tax productivity inequality is a subject left for future research.

7 Concluding remarks

The quest for an efficiency approach to the evaluation of policies with distributive impacts is longstanding. In a paper proposing his now-celebrated compensation test, Hicks (1939) ended by arguing that, because of the distortionary cost of compensation, “we shall have to reject on these grounds many measures which would be approved of by the traditional analysis.”²⁵ Harberger (1978) rejected distributional weighting

²³A number of versions of the separability restriction have been considered in the previous literature. Thus Hylland and Zeckhauser (1979) showed that a sufficient condition for the unweighted Samuelson rule was that preferences take the form $U(\mathbf{x}, \mathbf{p}, \ell) = F(\mathbf{1} \cdot \mathbf{x} + b(\mathbf{p}, \mathbf{x}), \ell)$ where $\mathbf{1} \cdot \mathbf{x}$ is a composite commodity of private goods, and b is the benefit of the public good in monetary units. Boadway and Keen (1993) and Kaplow (2006b) and Kreiner and Verdelin (2012) showed the same for weakly separable utility functions in general, $U(\mathbf{x}, \mathbf{p}, \ell) = F(H(\mathbf{p}, \mathbf{x}), \ell)$. It is easily verified that weak separability of the direct utility function implies (33).

²⁴Kaplow (2006b) established the same result for a restricted version of the separability condition (33). Hylland and Zeckhauser (1979) and Shavell (1981) also developed unweighted Samuelson rules in the separable case for evaluating policy reforms that are compensated through the income tax system.

²⁵This view was echoed by Samuelson (1958) who called for analysis of “the problem of ‘the feasible optimum’ along the lines of Ramsey and Boiteux.” (p. 540)

of individual surplus, arguing that it could lead to adoption of highly inefficient reforms mainly to achieve a redistributive goal, when other methods of redistribution could achieve the same at lower cost.²⁶ But Harberger recognized that compensating economic losses from reforms through the income tax system would be costly, and recommended a rough rule-of-thumb in which distributional transfers would receive a weight of 10 percent to reflect this. Coate (2000) and Hendren (2020) in turn outlined a more formal version of the Hicks–Harberger proposal involving feasible compensation.

In our approach evaluating policies for which there can be winners and losers, we include not only the net benefits of the policy itself, but also the net costs of compensating individuals using through the income tax, presuming it to be the most efficient means of delivering compensation. The measure of net benefits we use is the excess burden, which includes both the benefits household receive measured by the CV and the revenue costs to the government from both the policy change and the compensation. This measure generalizes that used by Harberger (1978). We show that the unweighted sum of excess burdens is identical both to the change in government tax revenue and to the change in production in the economy. Importantly, our approach is explicitly developed with large projects in mind.

Our underlying criterion is an unweighted sum of excess benefits of the compensated policy change, where the sum includes excess benefits arising from the distortionary compensation itself. We show how this unweighted sum of excess benefits can be transformed into a weighted sum of excess benefits of the policy alone, where the effects of compensation are incorporated into the weights. The weights are based on measurable elasticities so are sufficient statistics, and they are different from the weights derived by Hendren (2020). Our approach offers a formal derivation of cost-benefit rules that are in the spirit of what was proposed by Hicks (1939) and Harberger (1978).

We have derived distributionally sensitive cost-benefit rules for a particular type of policy, that involving price changes resulting from commodity tax changes or regulations. We showed how it could be adapted to other government policies such as public investment projects, as in Hylland and Zeckhauser (1979). It could also be used to evaluate economic shocks, such as wage rate shocks as in Schulz et al. (2022). Policies or exogenous events such as these could have an intertemporal dimension, and our approach could be adopted to take this into account. This might be particularly challenging for longer term policies, like carbon pricing, which have their effects over long multiple generations of persons. Analyzing compensation in this case would be conceptually difficult, not least because of the need for governments to commit to compensation for future generations.

²⁶As Harberger put it, “Never attribute to an action a benefit that exceeds the alternative cost of achieving the same result.”

Appendix

Proof of Corollary 1. Using (7), the post-reform budget constraint is

$$\mathbf{p} \cdot \mathbf{x} - w\ell = n = n^0 + E(\mathbf{p}, w) - E(\mathbf{p}^0, w^0)$$

Hence, totally differentiating and using Shepherd's lemma,

$$\mathbf{c} \cdot d\mathbf{x} = wd\ell - (\mathbf{p} - \mathbf{c}) \cdot d\mathbf{x} = (1 - T')dy - (\mathbf{p} - \mathbf{c}) \cdot d\mathbf{x} \quad (\text{A2})$$

Proposition 1 shows that $dg = dy - \mathbf{c} \cdot d\mathbf{x}$. Substituting (A2) yields

$$dg = T'dy + (\mathbf{p} - \mathbf{c}) \cdot d\mathbf{x}$$

Integrating this expression over y yields (10). \square

Proof of Lemma 1. To economize on notation, we let $z = y^0$ denote the income level reported by an agent of a given type in the status quo economy. Since income is strictly increasing in productivity type under our assumptions, we can write $a(z)$ as the type of agents reporting z in the status quo. Likewise, let $y(z)$ denote the income reported in the post-reform equilibrium by agent type $a(z)$.

Let

$$m^i(y) = y - T^i(y) \quad i = 0, 1 \quad (\text{A3})$$

denote the after-tax income functions, and observe that by (2)

$$w^i(y) = am^{i'}(y) \quad \text{and} \quad n^i(y) = m^i(y) - ym^{i'}(y) \quad (\text{A4})$$

The compensation condition (6) therefore holds for $m^1(y)$ if and only if

$$V(\mathbf{p}^1, a(z)m^{1'}(y), m^1(y) - ym^{1'}(y)) = V(\mathbf{p}^0, a(z)m^{0'}(z), m^0(z) - zm^{0'}(z)) \quad \forall y = y(z) \quad (\text{A5})$$

This is a functional equation in $m^1(\cdot)$ and $y(\cdot)$ that must be satisfied at the compensated post-reform equilibrium. Let

$$\tilde{V}^i(z) = V(\mathbf{p}^i, a(z)m^{i'}(y^i(z)), m^i(y^i(z)) - y^i(z)m^{i'}(y^i(z))) \quad (\text{A6})$$

denote the utility in equilibrium $i = 0, 1$ of an agent who reports income $y^0(z) = z$ in the status quo $i = 0$ and $y^1(z)$ after the reform. Note that, since $aV_w^i = V_n^i y^i$ (Roy's theorem),

$$\frac{\partial \tilde{V}^i(z)}{\partial z} = V_n(\mathbf{p}^i, w^i, n^i) m^{i'}(y^i) y^i \frac{\dot{a}(z)}{a(z)} \quad (\text{A7})$$

where (w^i, n^i) are the parameters of the linearized income tax system at y^i as defined in the main text of the paper.

The compensated income tax system $m^1(z)$ must therefore satisfy

$$\tilde{V}^1(z) = \tilde{V}^0(z) \quad \text{for all } z \in \text{supp } F^0. \quad (\text{A8})$$

Since this is an identity that holds on a set with non-empty interior, the derivatives of the two functions must also be equal for all z in the interior of $\text{supp } F^0$. Applying (A7), it follows that

$$m^{1'}(y^1)y^1 = \frac{V_n(\mathbf{p}^0, w^0, n^0)}{V_n(\mathbf{p}^1, w^1, n^1)} m^{0'}(y^0)y^0 \quad \text{for almost all } y^0.$$

Substituting (A3) then yields (15) \square

Derivation of (16). Since $V(\mathbf{p}, w, E(\mathbf{p}, w, u)) = u$, we know that $E_u(\mathbf{p}, w, u^0) = 1/V_n(\mathbf{p}, w, n)$. Moreover, $m^i(y) = y - T^i(y)$ implies that $m^{i'} = a(1 - T^{i'})$. Hotelling's lemma implies that $m^{i'}y^i = -aw^i E_w(\mathbf{p}^i, w^i, u^0)$. We can therefore write (15) as

$$\begin{aligned} m^{1'}(y^1)y^1 &= \frac{V_n(\mathbf{p}^0, w^0, n^0)}{V_n(\mathbf{p}^1, w^1, n^1)} m^{0'}(y^0)y^0 \\ \iff w^1 E_w(\mathbf{p}^1, w^1, u^0) &= \frac{E_u(\mathbf{p}^1, w^1, u^0)}{E_u(\mathbf{p}^0, w^0, u^0)} w^0 E_w(\mathbf{p}^0, w^0, u^0) \end{aligned}$$

Dividing by $E_u(\mathbf{p}^1, w^1, u^0) > 0$ yields (16). \square

Proof of Lemma 2. Differentiating (16), the marginal change in the after-tax wage for any small reform $d\mathbf{p}$ is

$$dw = \sum_i \frac{\partial w(\mathbf{p}, u^0)}{\partial p_i} dp_i \quad (\text{A9})$$

where

$$\begin{aligned} \frac{\partial w(\mathbf{p}, u^0)}{\partial p_i} &= -\frac{E_{iw}/E_w - E_{iu}/E_u}{E_{ww}/E_w - E_{wu}/E_u + 1/w} \\ &= \frac{\hat{\varepsilon}_{iw}}{1 + \hat{\varepsilon}_{\ell w}} \frac{x_i}{\ell} \end{aligned} \quad (\text{A10})$$

where we have used the Slutsky decomposition (18) and the definitions of uncompensated demands to write

$$\begin{aligned} \hat{\varepsilon}_{jw} &= -wl \left(\frac{E_{jw}}{E_w E_j} - \frac{E_{ju}}{E_u E_j} \right) \\ \hat{\varepsilon}_{\ell w} &= -wl \left(\frac{E_{ww}}{E_w E_w} - \frac{E_{wu}}{E_u E_w} \right) \end{aligned}$$

The marginal change in labor income is obtained by differentiating $y(\mathbf{p}, w, u^0) = -aE_w(\mathbf{p}, w, u^0)$ with $w = w(\mathbf{p}, u^0)$ to obtain

$$\begin{aligned} dy &= -a \sum_i \left[E_{wi}(\mathbf{p}, w, u^0) + E_{ww}(\mathbf{p}, w, u^0) w_i(\mathbf{p}, u^0) \right] dp_i \\ &= -\frac{a}{w} \sum_i \left[\frac{w E_{iw}}{E_i} - \frac{w E_{ww}}{E_w} \frac{\hat{\varepsilon}_{iw}}{1 + \hat{\varepsilon}_{\ell w}} \right] x_i dp_i \end{aligned} \quad (\text{A11})$$

using Hotelling's lemma, Slutsky symmetry, and (A10). Substituting the elasticity definitions then yields (19). \square

Proof that Lemma 2 implies Corollary 3 in the separable case. In the main text of the paper, we proved (Corollary 3) that our cost-benefit test was equivalent to unweighted total excess burden in the case of separable preferences for large reforms, without assuming differentiability. Here, we verify that the general formula in Lemma 2 reduces to the unweighted excess burden criterion, assuming that U is twice continuously differentiable.

Given the separable form of preferences (12), let $e(\mathbf{p}, v) = \min\{\mathbf{p}\mathbf{x} : \phi(\mathbf{x}) = v\}$ be the expenditure function for commodity demands, and define $L(v, u)$ as the associated labor supply satisfying $H(v, L(v, u)) = u$. The expenditure function can be written

$$E(\mathbf{p}, w, u) = \min_v e(\mathbf{p}, v) - wL(v, u) = e(\mathbf{p}, v(\mathbf{p}, w, u)) - wL(v(\mathbf{p}, w, u), u)$$

where the first-order condition defining optimal subutility $v(\mathbf{p}, w, u)$ is $e_v = wL_v$. Applying Hotelling's lemma gives compensated demand and supply functions $E_i = e_i(\mathbf{p}, v)$ and $E_w = -L(v, u)$. Differentiating implies

$$\begin{aligned} E_{ww} &= -L_v v_w & E_{ui}/E_{wi} &= v_u/v_w \\ E_{uw} &= -L_v v_u - L_u & E_u &= -wL_u \end{aligned}$$

Therefore

$$E_{ww} \frac{E_{ui}}{E_{wi}} - E_{uw} + \frac{E_u}{w} = -L_v v_u + L_v v_u + L_u - L_u = 0 \quad (\text{A12})$$

To express (A12) in elasticity form, note that

$$\begin{aligned} 0 &= E_{ww} \frac{E_{ui}}{E_{wi}} + \frac{E_u}{w} - E_{uw} \\ &= \frac{E_u E_i}{w^2 E_{wi}} \left[\frac{w E_{ww}}{E_w} \cdot w \frac{E_{ui}}{E_u} \frac{E_w}{E_i} + \frac{w E_{wi}}{E_i} \left(1 - \frac{w E_{uw}}{E_u} \right) \right] \end{aligned}$$

Substitute the elasticity definitions and Slutsky decomposition (18)

$$\varepsilon_{iw} - \hat{\varepsilon}_{iw} = w \frac{E_{iu}}{E_u} \frac{E_w}{E_i} \quad \varepsilon_{\ell w} - \hat{\varepsilon}_{\ell w} = w \frac{E_{wu}}{E_u}$$

to get

$$0 = \frac{E_u E_i}{w^2 E_{wi}} [\varepsilon_{\ell w}(\varepsilon_{iw} - \hat{\varepsilon}_{iw}) + \varepsilon_{iw}(1 - \varepsilon_{\ell w} + \hat{\varepsilon}_{\ell w})] \implies \frac{\varepsilon_{iw}}{\hat{\varepsilon}_{iw}} = \frac{\varepsilon_{\ell w}}{1 + \hat{\varepsilon}_{\ell w}}$$

This establishes that uncompensated and compensated wage elasticities are proportional for all commodities i under separability, so that $dy = 0$ in (19) for all compensated reforms $d\mathbf{p}$. \square

Proof of Proposition 2. Differentiating $x_i = E_i(\mathbf{p}, w, u^0)$ and $y = -aE_w(\mathbf{p}, w, u^0)$ with $w = w(\mathbf{p}, u^0)$ yields

$$\begin{aligned} dy &= -a \sum_j \left[E_{wj} + E_{ww} \frac{\partial w}{\partial p_j} \right] dp_j \\ dx_i &= \sum_j \left[E_{ij} + E_{iw} \frac{\partial w}{\partial p_j} \right] dp_j \end{aligned}$$

Substituting for dy and dx_i in (10),

$$\begin{aligned} dg &= T' dy + \sum_i (p_i - c_i) dx_i \\ &= - \sum_j \left[a E_{wj} + a E_{ww} \frac{\partial w}{\partial p_j} - \sum_i (p_i - c_i) \left(E_{ij} + E_{iw} \frac{\partial w}{\partial p_j} \right) \right] dp_j \\ &= - \sum_j \left[\frac{a T'}{w} \left(\frac{w x_{jw}}{x_j} - \frac{w \ell_w}{\ell} \omega_j \right) - \sum_i \frac{p_i - c_i}{p_i} \left(\frac{p_i x_{ji}}{x_j} - \frac{p_i \ell_i}{\ell} \omega_j \right) \right] x_j dp_j \end{aligned}$$

where we have used Slutsky symmetry, and

$$\omega_j = \frac{\ell}{x_j} \frac{\partial w(\mathbf{p}, u^0)}{\partial p_j} = \frac{\hat{\varepsilon}_{iw}}{1 + \hat{\varepsilon}_{\ell w}}$$

denotes the amount by which after-tax labor income $w\ell$ must rise, per dollar of increase in expenditures $x_i dp_i$.

Recall that $w/a = 1 - T'$, and let $p_i/c_i = 1 + \tau_i$ where τ_i is the percentage price distortion for commodity i . Then this expression states

$$dg = - \sum_j \left[\frac{T'}{1 - T'} (\varepsilon_{jw} - \varepsilon_{\ell w} \omega_j) - \sum_i \frac{\tau_i}{1 + \tau_i} (\varepsilon_{ji} - \varepsilon_{\ell i} \omega_j) \right] x_j dp_j \quad (\text{A13})$$

Integrating (A13) over individuals yields (21). \square

Proof of Proposition 3. (30) implies that

$$\begin{aligned} deb(\mathbf{p}, w, u^0) &= \sum_k \left[E_k(\mathbf{p}, w, u^0) + f_k^*(p, u^0) - (a - w) \frac{d}{dp_k} \ell(\mathbf{p}, w(\mathbf{p}, u^0), u^0) \right] dp_k \\ &= - \sum_k \left[(q_k - f_k^*) dp_k + \frac{a - w}{a} dy \right] \end{aligned}$$

where we have used $E_w = -\ell$ and $dy = ad\ell$. Noting $w = a(1 - T')$ then yields (32).

Proof that (33) implies the Samuelson rule. The first-order condition for labor supply on the linearized budget constraint is

$$w = e_\ell(p, \ell, u^0) = \hat{e}_\psi(p, \psi)\psi_\ell(\ell, u^0) \quad (\text{A14})$$

Hotelling's lemma implies that

$$E_u(p, w, u^0) = e_u(p, \ell, u^0) = \hat{e}_\psi(p, \psi)\psi_u(\ell, u^0) \quad (\text{A15})$$

Substituting (A14)–(A15) into (18) implies

$$\frac{\psi_\ell(\ell^1, u^0)\ell^1}{\psi_u(\ell^1, u^0)} = \frac{\psi_\ell(\ell^0, u^0)\ell^0}{\psi_u(\ell^0, u^0)}$$

The left-hand side of this equation is strictly monotone in ℓ^1 , given the assumption that labor income is strictly monotone in wage rates. Therefore, the unique solution has $\ell^1 = \ell^0$. \square

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