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Guidelines on Searching for a Dalton-Improving Tax Reform: An Illustration with Data from Indonesia

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This article documents the search for a Dalton-improving tax and expenditure reform using a methodology developed by Yitzhaki and Slemrod (1991) and Mayshar and Yitzhaki (1995). The methodology overcomes the need to define a specific social welfare function by searching instead for reforms that improve each social welfare function belonging to a wide class of functions. The authors apply the method to the energy sector of Indonesia, ignoring distributional constraints, and find that both the subsidy on kerosene and the tax on gasoline should be reduced. But taking distributional concerns into account, the present structure of energy taxes is reasonable and the country may benefit by increasing the subsidy to kerosene, taxing electricity, and reducing the gasoline tax. These conclusions are robust to changes in the relevant parameters representing the Indonesian economy.

This article illustrates the search for a Dalton-improving tax and expenditure reform using a methodology developed by Yitzhaki and Slemrod (1991) and Mayshar and Yitzhaki (1995).[1] The goal of this methodology is to eliminate the need to define a specific social welfare function. Instead, we search for reforms that improve each social welfare function belonging to a wide class of functions. Avoiding the definition of a specific social welfare function reduces the bias often inherent in such reforms: because governments are unable to specify a social welfare function on their own, the proposed reforms often represent the social views of advisers, which need not coincide with those of the client governments. Although professional advice on income distribution is never value free, use of the Dalton-improving principle reduces the significance of the value judgments embedded in such advice.

Dalton-improving reforms require the same data as social welfare-based tax reforms. Thus no savings are made with respect to data collection. But the reliance on data is weaker under Dalton-improving reforms. For example, both

1. See Martina (1993) for applications of the methodology in other areas of economics.

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types of reforms require revenue estimates; although regular reforms may be sensitive to the exact magnitude of these estimates, Dalton-improving reforms are not affected if the estimates are multiplied by a constant.

I. The Search for a Dalton-Improving Reform

Hugh Dalton, a British economist, was the first to suggest that a transfer from a rich person to a poor person increases social welfare (Dalton 1949). Dalton improvement is weaker than Pareto improvement, which asserts that society benefits if the income of at least one member increases, provided that the incomes of all other members do not fall. By contrast, a Dalton-improving reform allows the income of an individual to fall, provided that the incomes of one or more poorer individuals increase by at least the same amount.

Searching for a Dalton-improving reform first requires ranking the population according to its economic well-being. A definition of well-being must be agreed upon to allow determination of who is rich and who is poor; such a distinction is needed to decide whether a transfer will increase or decrease social welfare. The definition of well-being can be expanded; for example, Mayshar and Yitzhaki (forthcoming) allow well-being to be affected by two parameters—ability and needs. Given ability, the greater the needs, the lower the well-being of a household; and, given needs, the greater the ability of the household, the higher its well-being. This kind of extension is useful for handling family size, in which needs increase with the number of children, or rural-urban distinctions, in which rural populations might need less income to achieve a certain level of well-being than do urban populations (Ravallion 1993).

The technical requirements and implications of such extensions are beyond the scope of this article. Instead, the empirical illustration reported later uses expenditure per capita as the sole indicator of economic well-being. Because expenditure per capita is used only to rank households, any monotonic transformation of this measure can be used without affecting the findings.

Dalton described the effect of transfers from rich to poor—not of transfers between equally rich or equally poor individuals. Differential treatment of equally rich or poor individuals is referred to as horizontal inequity. In our analysis we allow transfers to be made between individuals that are equally well-off; furthermore, we assume that society is indifferent to such transfers. This assumption enables us to aggregate households with equal economic well-being.[2]

Types of Reform

We restrict the search for a Dalton-improving reform to finding the direction of the desired tax reform (that is, determining which taxes or subsidies will in-

2. Note that indirect taxes tend to tax equal individuals differently. For a discussion of different interpretations of horizontal inequity, see Lambert and Yitzhaki (1995). Mayshar and Yitzhaki (forthcoming) extend the method to deal with Dalton-improving reforms in which transfers between certain types of individuals are not allowed.

crease or decrease and in what proportions), rather than the exact magnitudes of changes in tax rates. The methodology of a Dalton-improving reform is applicable to nonmarginal reforms. However, we will restrict the application to marginal reforms. The main advantage is the smaller data requirements: the analysis of a marginal reform relies mostly on observed data, while analysis of a nonmarginal reform typically relies on estimated or synthetic data on households.

An immediate question arises: How restrictive is the assumption of a marginal reform, and does this assumption make the methodology irrelevant for evaluating practical tax reforms? Technically, an approximation based on knowing only the appropriate direction is applicable whenever first-order approximations do not lead to gross errors. But this textbook answer is not very useful. Looking further, Willig (1976) investigated the accuracy of estimates of consumer surplus from demand curves and showed that such approximations depend on a commodity's share in total consumption and on income elasticities. The smaller the share, the greater the accuracy—that is, the less a change in a commodity's price affects the accuracy of the approximations. Similarly, the higher the income elasticity, the less accurate are the approximations.

Also critical are the properties of Dalton-improving reforms. Empirically, it is important that the reforms do not drastically change the household ranking. A useful rule of thumb holds that if the reform does not change incomes by more than 10 percent, a marginal analysis is reasonable. But if one intends to make the poor rich and the rich poor, marginal analysis is not appropriate.

Tax-Shifting Assumptions

Tax-shifting assumptions allow for additional data savings. A general equilibrium model is required to determine the distributional effect of the portion of the tax absorbed by firms, households (the suppliers of factors of production), and the economy. Most computable general equilibrium (CGE) models generally assume that all production functions are homogeneous of degree one and that there is perfect competition—which is equivalent to assuming that taxes are borne by consumers. For simplicity we assume such shifting to consumers as well, although there is nothing in the method that prevents the introduction of complex tax shifting into the calculations.

Revenue Neutrality

It is easier to analyze revenue-neutral reforms because we can ignore the issue of the optimal size of government activity. But ignoring this issue is another convenient assumption and can be discarded, provided that the appropriate data—each household's willingness to pay for public goods—are available. Partial relaxation of this requirement will be illustrated later.

Externalities

Ignoring externalities is yet another simplifying assumption. It should not be difficult, however, to incorporate the effects of externalities into the calcula-

tions, provided that we can obtain the appropriate data or, alternatively, make the necessary assumptions regarding the effect of the externalities. If externalities affect a public good, then we would need to know each household's willingness to pay. Eskeland and Kong's (1994) framework is a good example of an approach that can be incorporated into the search for Dalton-improving reforms.

II. Characterization of a Dalton-Improving Reform

Consider a household with a well-behaved utility function $u^h(\cdot)$, unknown to us, and a known budget allocation, $y^h = \sum_i q_i x_i^h$, where q_i is the consumer price of the ith commodity; x_i^h is the quantity of that commodity consumed; and y^h is the household's exogenously given income. Commodities may include factors of production, such as labor, in which case the consumed quantity of the commodity is nonpositive. Assume that producers' prices (p_i for the ith good) are given and that $t_i = q_i - p_i$ are the tax rates. Then, the effect of a marginal tax reform on the household, or marginal benefit, is

$$MB^h = -\sum_i x_i^h dq_i + dy^h.^3 \tag{1}$$

A Dalton-improving reform can be viewed as the combination of the allocation of manna from heaven (arriving because of a reduction in deadweight efficiency loss, or excess burden) and transfers from rich to poor households. MB^h is the first-order approximation of the effect of the reform on household h, evaluated in monetary terms.

Under the Dalton criterion, $MB^1 \geq 0$ must hold for the poorest (first) household, otherwise the poorest household has not received its share of manna or a transfer from a richer household. If $MB^1 < 0$, the poorest household is making a transfer to others, in violation of the Dalton criterion.

Now consider the second poorest household. The Dalton criterion restriction on the marginal benefit to this household requires that $MB^1 + MB^2 \geq 0$, which means that the combined first and second household "poor" must be better off. Note that MB^2 can be negative, in which case the reform involves a transfer from the second poorest to the poorest household.

By similar reasoning, it can be shown that a Dalton-improving reform has to fulfill the general condition

$$\sum_{h=1}^{k} MB^h \geq 0, \text{ for } k = 1, 2, 3 \ldots H, \tag{2}$$

where H is the number of households in the economy.

We can offer an additional interpretation of equation 2. Consider a social planner who wants to reduce the poverty gap but does not know who is

3. We can derive this relationship under two alternative sets of assumptions. First, the household is a utility maximizer, and, by Roy's identity, $\partial v^h(\cdot)/\partial t_i = -\lambda^h x_i^h$, where v is the indirect utility function and λ is the marginal utility of income. The marginal benefit is the income equivalent of the change caused by the reform. Second, no optimization is carried out by the household, and we are interested only in a Slutsky compensation to the household.

poor. To be on the safe side, it is best to reduce poverty gaps for *any* possible poverty line. Equation 2 is the necessary and sufficient condition for such a strategy.

A simple change in equation 2 will allow us to adapt the Dalton-improving reform to more specific poverty criteria. If the social planner is willing to commit to an upper bound for the poverty line, then equation 2 can be restricted to the subset of households that are potentially poor, and all other households can be aggregated into one group. Another poverty target is to insist that the reform raise all incomes above a given threshold. Accommodating such a restriction requires that additional constraints be imposed on the lowest inequalities in equation 2. Such an extension is feasible but beyond the scope of this article.

III. Tax Instruments

Equation 2 defines the target function for the tax reform, which is subject to the constraint that the reform be revenue neutral. Each tax instrument (which may be a tax rate, an exemption, or any aspect of the tax function) involved in the reform is characterized by two kinds of parameters. The first parameter reflects the effect on the target function and is later referred to as the *distributional characteristics* of the instrument.[4] The second parameter reflects the impact on the revenue constraint and is referred to as the marginal efficiency cost of public funds (MECF). The MECF reflects the cost to society of the revenue raised by changing the tax instrument.

Distributional Characteristics

Substituting equation 1 into the left-hand side of equation 2 gives

$$\sum_{h=1}^{k} MB^h = -\sum_{h=1}^{k} \sum_i x_i^h dq_i + \sum_{h=1}^{k} dy^h. \tag{3}$$

By changing the order of summation and dividing and multiplying by $X_i = \sum_h x_i^h$, the "quantity demanded" of the tax base i (which for indirect taxes is commodity i), we get

$$\sum_{h=1}^{k} MB^h = -\sum_i X_i dq_i \left(\sum_{h=1}^{k} x_i^h / X_i\right) + \sum_{h=1}^{k} dy^h. \tag{4}$$

The term $\sum_{h=1}^{k} x_i^h / X_i$ is the cumulative share of commodity i consumed (held) by the k poorest households. This term reflects the distributional characteristics of the tax instrument. It is portrayed by the concentration curve of the commodity, which is a variation of the well-known Lorenz curve (Kakwani 1977 describes the properties of concentration curves).

The data required for constructing concentration curves can be found in any survey of family expenditure. In this article we use the National Social Economic Survey, or SUSENAS (Government of Indonesia 1990). Since we deal only with indirect tax reforms, $dy^h = 0$ for all households.

4. Feldstein (1972) coined the term distributional characteristics and showed its relevance in taxation.

Marginal Costs of Funds

An important consideration in any tax reform is the expected change in revenue. In this section we show that embedded in these revenue estimates is the estimate of the marginal deadweight loss that can be recovered through the revenue estimates.

Government tax revenue is

$$R(t,p,y) = \sum_i t_i X_i(p+t,y) \tag{5}$$

where $X_i(q, y)$ is the demand for commodity i; y is a vector of incomes; t is a vector of specific taxes; and consumer prices are $q = p + t$. Revenue neutrality requires that

$$dR = \sum_i MR_i dt_i = 0 \tag{6}$$

where $MR_i = \partial R/\partial t_i$ is the change in overall tax revenue resulting from a small change in the tax rate on commodity i. As it turns out, it is convenient to work with revenue changes expressed in monetary terms rather than with tax parameters, which may have different units. Hence the change in tax revenue (denoted by δ_i) that results from a change in the tax rate on commodity i (dt_i) becomes

$$\delta_i = MR_i dt_i. \tag{7}$$

The marginal tax reform, dt, could also be characterized by the vector of tax receipts, δ. And the change in tax revenue would then be $dR = \sum_i \delta_i$.

Substituting equation 7 into equation 4 and taking into account that $dt_i = dq_i$ and $dy^h = 0$ for all h, the Dalton criterion becomes

$$\sum_{h=1}^{k} MB^h = -\sum_i (X_i / MR_i)\delta_i \left(\sum_{h=1}^{k} x_i^h / X_i\right) \geq 0, \quad \text{for } k = 1,2\ldots H \tag{8}$$

subject to $\sum_i \delta_i = 0$.

The term X_i/MR_i is the marginal efficiency cost of public funds. To illustrate, we concentrate on the last inequality in equation 8, when $k = H$. This is the representative consumer case in which distributional considerations are ignored. Equation 8 becomes

$$\sum_{h=1}^{H} MB^h = -\sum_i (X_i / MR_i)\, \delta_i \text{ subject to } \sum_i \delta_i = 0. \tag{9}$$

A neutral tax reform, involving only two taxes, will reduce deadweight loss if

$$\sum_{h=1}^{H} MB^h = -[(X_1 / MR_1)\, \delta_1 - (X_2 / MR_2)\, \delta_1] = (MECF_2 - MECF_1)\delta_1 > 0. \tag{10}$$

It can be easily seen that if $MECF_2 > MECF_1$, the reform will have an efficiency gain only if $\delta_1 > 0$, and if $MECF_2 < MECF_1$, the reform will have an efficiency gain only if $\delta_1 < 0$.[5]

5. Note that if any two MECFs are not equal, then we can design a Pareto-improving tax reform, provided that lump-sum taxes exist.

To estimate the marginal efficiency cost of public funds, two parameters for each tax instrument must be evaluated: the marginal change in revenue, MR_i, and the tax base X_i, which is the expected change in tax revenue assuming no other changes occur.

In many estimations, X_i is also used as an estimate of MR_i. The interpretation in those cases is that all marginal efficiency costs of public funds are assumed to be equal. But in this article we relax this simple assumption and use a CGE model for Indonesia that can estimate these costs individually (Lewis 1993). A brief description of the model is given in the appendix.

Characterization of the Solution

The problem solved is that defined in equation 8. That is, we must determine the $\delta_i (i = 1. . .n)$ that satisfy the inequalities in that equation. In many cases equation 8 will have no feasible solution or an infinite number of solutions. We will be interested in finding one feasible solution, and, if possible, characterizing the feasible set. Since the trivial solution, $\delta_i = 0$ for all i, satisfies the constraints, one commodity should be chosen as a numeraire, with $\delta = 1$ or $\delta = -1$. We must try both cases because we do not know whether the tax on the numeraire should be increased or decreased. Also, any convex combination of two solutions is feasible.[6] Thus by finding two Dalton-improving tax reforms, one with a positive change in the tax rate j and the other with a negative change, we can find a Dalton-improving reform with no change in tax rate j. In this case we can conclude that instrument j is not essential for a Dalton-improving reform.

In order to search for solutions, a numerical optimization algorithm is used to solve the following problem:

$$(11) \qquad \underset{\delta}{Min} \sum_k \{Max\,[-CMB^k(\delta),0]^2\}, \text{ subject to } \sum_i \delta_i = 0; \delta_1 \neq 0$$

where $CMB^k = \sum_{h=1}^{k} MB^h$ is the cumulative marginal benefit of all households poorer than or just as poor as household k. A feasible marginal tax reform, δ, will be considered a solution if the value of the objective function in equation 11 is zero. Since a solution requires that the target function equal zero, it is easy to verify that the numerical optimizer reaches a solution. The algorithm used for the search is described in Yitzhaki (1982), but any algorithm for numerical optimization can be used.

In general, there may be several (or an infinite number of) solutions to equation 11, and we do not have a methodology for finding all of them. For each numerical problem that we solve, we may find one solution. But it can be shown that the set of solutions forms a convex cone, implying that for a small number of instruments we can characterize the whole efficient set. For example, if only three tax rates are considered, then there will be only one

6. To see this, note that a "solution" means that the cumulative gain is nonnegative for all k ($\sum_{h=1}^{k} MB^h \geq 0$). Imagine that you have found two such solutions. Then any convex combination of the two will also be nonnegative for all k.

independent variable, and the efficient set will form a segment on the real line. Searching for extreme solutions enables us to wholly characterize the efficient set.

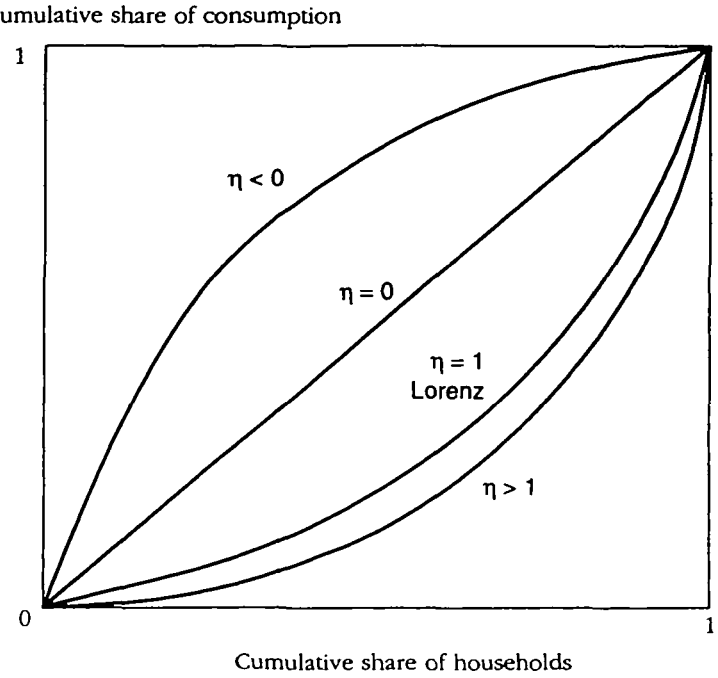
The set of solutions to equation 11 defines the feasible set of Dalton-improving reforms. In general, we will be satisfied if we find one solution that belongs to the set. If the set includes more than one solution and we can characterize the whole set, the question to be asked is how to choose among solutions. One possibility is to add other constraints. For example, we could require that a Dalton improvement take place for both rural and urban populations or, alternatively, for several subgroups of the population, such as different-size households (see Mayshar and Yitzhaki, forthcoming). Another possibility is to choose a Dalton-improving reform that maximizes the number of beneficiaries—making it the most "populist" option. Those extensions are beyond the scope of this article.

IV. More on Distributional Characteristics

Ignore, for the time being, the marginal cost of funds. We can assume that taxes are lump sum, or that their marginal efficiency costs of public funds are equal. The distributional characteristics of a tax instrument are described by a concentration curve. The concentration curve of commodity j depicts the cumulative share of aggregate expenditure on that commodity against the ranking order of households, which are arranged in increasing order of economic well-being. The concentration curve is constructed analogously to the Lorenz curve, except that the vertical axis represents the cumulative share of a tax base (commodity) rather than income. By construction, each concentration curve extends from zero (for $h = 0$) to 1 (for $h = H$). The income elasticity of the commodity can be inferred from the curvature: if the concentration curve is convex, then the income elasticity is greater than zero; if the curve is concave, the elasticity is negative; and if it is a straight line, the elasticity is zero. An inferior good will thus have a concentration curve above the diagonal, and the curve of a neutral good will coincide with the 45-degree line. If the income elasticity is one, the Lorenz and the concentration curves will be identical, and if the elasticity is greater than one, the concentration curve will fall below the Lorenz curve. Since income elasticity can change over the range of the income distribution, it is possible for the concentration curve to follow an irregular path between the starting point (0, 0) and the ending point (1, 1) (figure 1).

In general, concentration curves tend to intersect, making it difficult to determine the characteristics of the appropriate Engel curve from their movements. This, in turn, makes it difficult to grasp the intuition and logic of Dalton-improving reforms. Fortunately, we can derive necessary conditions for Dalton-improving reforms using modified versions of regular income elasticities. For this purpose it is convenient to summarize the curvature of the concentration

Figure 1. *Distributional Characteristics of Commodities*



Note Cumulative share of households is from the lowest- to the highest-income. η is the (Gini) income elasticity of commodities.

curve by a coefficient, known as the Gini income elasticity of a commodity.[7] Construction of this coefficient is as follows.

The area between the Lorenz curve and the 45-degree line is equal to $\text{cov}[y, F(y)]/\mu_y$, where μ_y and $F(y)$ are the mean and the cumulative distribution of expenditure per capita, respectively. The term $\text{cov}[y, F(y)]$ resembles a variance measure, but with a cumulative distribution substituted for the variate. Similarly, the area between a concentration curve of commodity x_i and the 45-degree line is equal to $\text{cov}[x_i, F(y)]/\mu_i$, where μ_i is the mean expenditure on commodity i. Given the basic components that resemble the coefficient of variation and the covariance, the Gini income elasticity of a commodity is

$$\eta_i = \frac{\text{cov}[x_i, F(y)]\mu_y}{\text{cov}[y, F(y)]\mu_i}. \tag{12}$$

There are three interpretations of η_i:

- η_i is equal to the area between the 45-degree line and the concentration curve divided by the area between the 45-degree line and the Lorenz curve;

7. See Lerman and Yitzhaki (1994), Yitzhaki (1994), and the references therein for the derivation of the coefficient and other alternative interpretations of those coefficients.

- η_i is equal to a weighted average of the income elasticity of commodity i, with the weights derived from the Gini coefficient (Yitzhaki 1994);
- η_i is equal to the ratio of the Gini regression coefficient of the marginal propensity to spend on commodity i divided by the average propensity. To see that η_i resembles an elasticity, note that $b_i = \text{cov}[x_i, F(y)]/\text{cov}[y_i, F(y)]$ is the Gini regression coefficient of the slope of the regression curve of x as a function of y, which can be interpreted as a weighted average of the marginal propensity to spend, while μ_i/μ_y is the average propensity.[8]

An important property of this parameter is that a value greater or smaller than 1 determines whether a change in the tax on the commodity raises or lowers the Gini index of income inequality (Lerman and Yitzhaki 1994). Moreover, comparing the Gini income elasticities to each other and to 1 permits us to evaluate the impact of a tax on the Gini coefficient of economic well-being (Yitzhaki 1994).

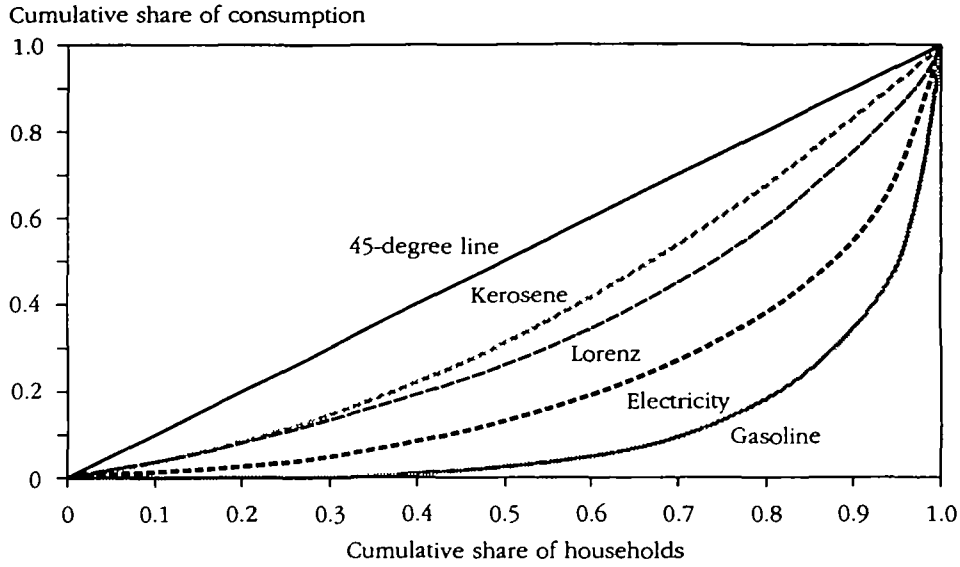
V. Distributional Characteristics of Commodities in Indonesia

The data we used came from the Indonesian Sample of Family Expenditure for 1990 (Government of Indonesia 1990). Expenditure per capita is used as a proxy for a household's economic well-being, and an individual is treated as the relevant unit by assigning a weight according to the number of individuals in the household. In order to simplify the calculations, the sample population is divided into 94 cells, each with 500 households (except for the last, which has 79 households).

As explained above, the marginal efficiency costs of public funds are calculated using a CGE model, derived from the 1985 social accounting matrix for Indonesia. One practical problem that arises when using two separate sources of data is the mismatching of classifications and levels of aggregation. On one hand, the family expenditure survey does not distinguish between imported and locally produced goods, although the CGE model was designed primarily to deal with such trade issues. On the other hand, the twenty-six-sector CGE model lacks the commodity detail of the expenditure survey. For example, it includes only one food processing sector, but the level of disaggregation in the survey goes as far as to distinguish between different types of cigarettes. To overcome this problem, we limited our search for Dalton-improving reforms to three commodities that are similarly defined in both data sources: electricity, kerosene, and gasoline. We also limited our analysis to the excise taxes or subsidies that were levied on these products. Historically, these rates have varied substantially. In 1980–81, for example, total subsidies to domestic fuel use averaged 17 to 18 percent of government routine expenditure, or nearly 2 percent of gross

8. For those who feel more comfortable with ordinary least squares (OLS), note that b_i can be interpreted as an instrumental variable estimator of the slope of the regression curve when $F(y)$ is used as an instrument for y.

Figure 2. *Concentration Curves of Energy-Producing Items, Indonesia*



Note: Cumulative share of households is from the lowest- to the highest-income.
Source: Authors' calculations.

domestic product (GDP); but by 1985 (the year of the data used in this study) the total subsidy had dropped to only about 3 percent of routine expenditure.

The commodity with the lowest concentration curve is gasoline, indicating that gasoline has the highest income elasticity, which is greater than 1 (figure 2). Next comes electricity, with a concentration curve that is also below the Lorenz curve, meaning that the income elasticity of electricity is, on average, greater than 1. The concentration curve of kerosene is below the diagonal and above the Lorenz curve, which means that the income elasticity is bounded by 0 and 1.

The (Gini) income elasticity of kerosene is 0.59, indicating that kerosene is a necessity, whereas electricity has an income elasticity of 1.61 and gasoline 2.30 (table 1). As shown in Yitzhaki (1991), these are consistent estimates of the appropriate population parameters, and the asymptotic distribution converges

Table 1. *Gini Income Elasticities of Commodities, Indonesia*

Elasticity	*Kerosene*	*Electricity*	*Gasoline*	*Q-cig.*[a]	*V-cig.*[b]
Income elasticity	0.59	1.61	2.30	0.26	0.56
	(0.07)	(0.05)	(0.14)	(0.09)	(0.07)

Note: Income elasticity is calculated with respect to expenditure per capita. The population includes all Indonesian households separated into 94 groups, each with 500 observations, except for the last group. Households are ordered according to expenditure per capita. Jackknife standard errors are reported in parentheses (see Yitzhaki 1991).

a. *Q*-cig. is the income elasticity of purchased quantity of regular rolled cigarettes.

b. *V*-cig. is the income elasticity of expenditure on regular rolled cigarettes.

Source: Government of Indonesia (1990); authors' calculations.

to the normal. We can see from the standard errors that the income elasticities of these commodities differ significantly from one another.

The income elasticity of regular rolled cigarettes is included in order to demonstrate some of the properties of the analysis. The difference between the income elasticity of quantity sold of regular rolled cigarettes and the income elasticity of expenditure on this commodity (0.56–0.26) indicates that the income elasticity of price paid is 0.3 (the difference between the two).[9]

VI. Dalton-Improving Reforms

To begin the search for Dalton-improving reforms, we ask the following question: Is it possible to have a revenue-neutral Dalton-improving reform that is based on the change in the taxation of one commodity? The answer is yes, if we can tax the quality of the commodity.

To see this, consider the following case. A specific subsidy (that is, a subsidy to the quantity consumed) and an ad valorem tax are simultaneously imposed on the same commodity. The rates are defined so that the reform is neutral ($\delta_{Quant.} = -\delta_{Expend.}$). Since the marginal cost of funds for each of these two taxes should be equal, the way of finding such a tax reform is by plotting the difference between the concentration curves of quantity consumed and expenditure on that commodity. The vertical difference between the concentration curves (the DCC curve) is the cumulative marginal benefit from the reform. If the curve is nonnegative, then a revenue-neutral, one-commodity tax reform is identified. The DCC curve for regular rolled cigarettes shows that the cumulative gain is positive—thus a Dalton-improving reform exists (figure 3). The bottom 70 percent of the population could gain up to 8 cents for each dollar of tax paid by the top 30 percent of the population.

The purpose in presenting this example is to demonstrate the importance of separating the tax instrument from the commodity. The same commodity could have different tax bases depending on the nature of the change in the tax function. A good example is motor vehicles. Many developing countries (including Indonesia) impose taxes on different properties, such as quantity (a constant amount per vehicle), weight, engine size, and, of course, value. The different taxes may have significant differences in their distributional characteristics, a property that can be exploited to increase the variety of tax instruments.

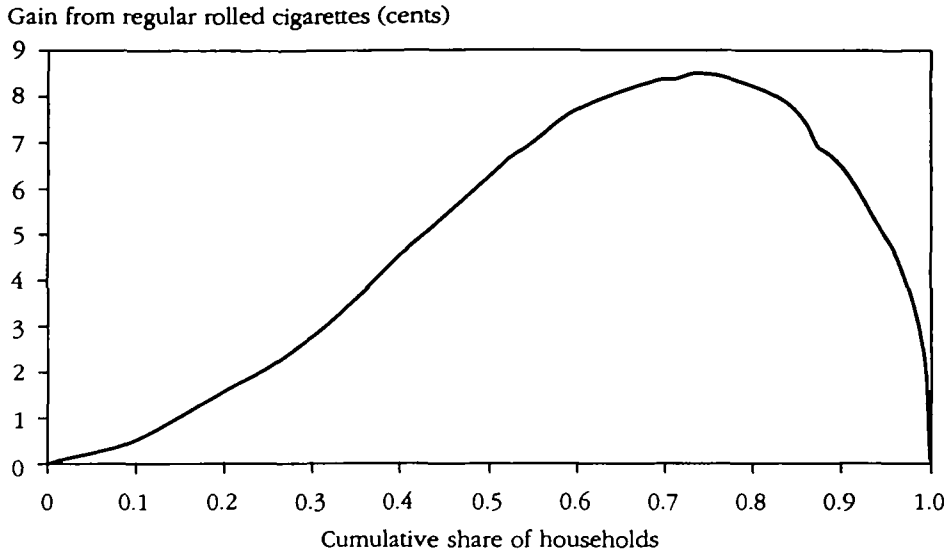
VII. Dalton-Improving Reforms Involving More Than One Commodity

In order to search for Dalton-improving reforms that involve more than one commodity, we need to determine the MECF of the commodities, which we cal-

9. To see this, note that $E = PQ$, where P is price and Q is quantity. Let Y be income. Then $\Delta E = P\Delta Q + Q\Delta P$. Hence:

$$\frac{\Delta E}{\Delta Y}\frac{E}{Y} = \frac{\Delta Q}{\Delta Y}\frac{Y}{Q} + \frac{\Delta P}{\Delta Y}\frac{Y}{P}.$$

Figure 3. *The Gain from a Combination of a Subsidy and a Tax, Indonesia*



Note: The figure plots the gain at each cumulative household share of a dollar of tax paid by the higher-income households above that level. Cumulative share of households is from the lowest- to the highest-income.
Source: Authors' calculations.

culate using the CGE model (table 2). If the tax planner cares only about efficiency, then the optimal policy is to equate the marginal efficiency costs of public funds. Comparing the income elasticities in table 1 with the MECFs in table 2, we see that the ranking of the two is equal, meaning that the structure of taxation of those commodities is reasonable in that a higher share of tax paid by the poor corresponds to a lower marginal excess burden. From this result we can conclude that the structure of Indonesian energy taxes does take into account distributional considerations.

The cost at the margin to society of raising a dollar of revenue from the gasoline tax is 2.7 dollars (figure 4). The burden on the poorest 50 percent of the

Table 2. *Parameters for Calculations of Marginal Efficiency Costs of Public Funds, Indonesia*

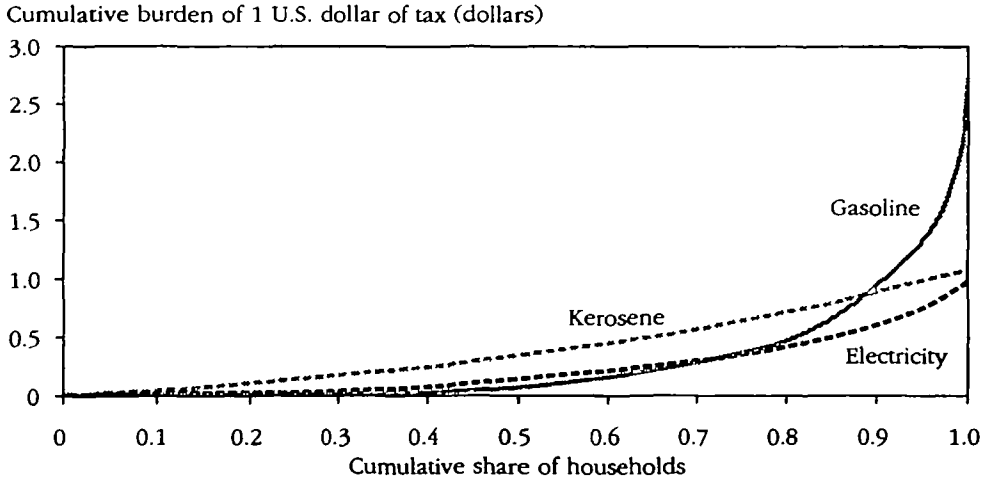
Variable	*Tax base, X (billions of 1985 Indonesian rupiah)*	*Marginal revenue from tax, MR (billions of 1985 Indonesian rupiah)*	*Marginal efficiency costs of public funds, MECF*	*Initial tax rate*
Kerosene	62.2	57.4	1.08	–0.48
Electricity	83.5	73.4	1.13	0.00
Gasoline	104.7	38.7	2.70	0.30

Source: Authors' calculations.

population is 12 cents, and the rest is borne by the wealthier half of the population. On the other hand, a dollar of revenue raised through a tax (reduction of the subsidy) on kerosene costs society only 1.08 dollar, but the poorest half of the population pays 40 cents. An economist guided by efficiency concerns would recommend that the subsidy to kerosene be reduced and the tax on gasoline lowered in order to reduce distortionary taxation. This measure would save society more than 1.5 dollars for each dollar reduction in the subsidy to kerosene. On the other hand, the economist who cares about distribution will point out that the burden of those taxes is not shared fairly. More of the burden of kerosene taxation is borne by the poor, so that a transfer of a dollar of taxation from gasoline to kerosene can be viewed as a transfer from the poor to the rich. This divergence between policy prescriptions based on efficiency alone and those based on equity alone confirms that the Indonesian taxes embody a reasonable tradeoff between objectives: although efficiency considerations call for reducing the gap in tax rates, distributional concerns point in the other direction.

Note that all curves in figure 4 intersect, meaning that it is impossible to find a Dalton-improving neutral tax reform that involves only two commodities. On the other hand, intersection points to the possibility of finding two different social welfare functions, both of which conform to the Dalton criterion. One function can justify raising the tax on one commodity and lowering the tax on the second, while the other function can show the opposite. The ability to find two social welfare functions that give contradicting recommendations means that it is impossible to find a Dalton-improving reform.

Figure 4. *Distributional Burden of Energy Taxes, Indonesia*



Note: Cumulative share of households is from the lowest- to the highest-income. Each curve is the concentration curve of the commodity multiplied by the marginal efficiency cost of public funds of that commodity.

Source: Authors' calculations.

Economists are neither equipped nor entitled to handle issues of fairness. In order to reach specific conclusions, social planners must be more specific with regard to their social preferences. We can say for certain only that the Indonesian taxation of the commodities we examined takes into account distributional concerns.

Having failed to find a Dalton-improving reform that is based on two commodities, we must search for a three-commodity reform. In this case, we have freedom to set only one tax: one tax change is used as a numeraire, so its value is either 1 or −1, and a second tax change is determined by the budget constraint. Since only one variable is free and the set of efficient Dalton-improving reforms is a cone, if a given set of Dalton-improving reforms is not empty, it forms a closed section on an interval.

Applying the optimization algorithm to this three-commodity question, we find that Dalton-improving, revenue-neutral reforms have the following structure: an increase in the tax on electricity and a decrease in the taxes (subsidies) on kerosene and gasoline (table 3). Reform D (distribution) says that each dollar reduction in the tax on kerosene is accompanied by a reduction in the tax on gasoline by 3.5 cents and an increase in the tax on electricity by 1.035 dollars. Reform E (efficiency) raises the tax on electricity by 3.26 dollars and reduces the tax on gasoline by 2.26 dollars for every 1 dollar reduction in the tax on kerosene. Any convex combination of those reforms is a Dalton-improving, revenue-neutral reform as well.

Reform D does not result in an efficiency gain to society, but it results in a gain to low-income groups (figure 5). To see the amount of efficiency gain, add up the products of the MECFs and the revenue changes (in table 3): $(1.0)(1.083) - (1.035)(1.13) + (0.035)(2.70) = 0.008$. Reform E results in an efficiency gain of 3.5 dollars for every dollar reduction in the tax on kerosene, but the gain is limited to high-income groups.

Now that we have identified a set of Dalton-improving reforms, we can consider the appropriate reform by introducing other considerations. Although the nature of these considerations can vary from one country to another, a few possibilities include the following:

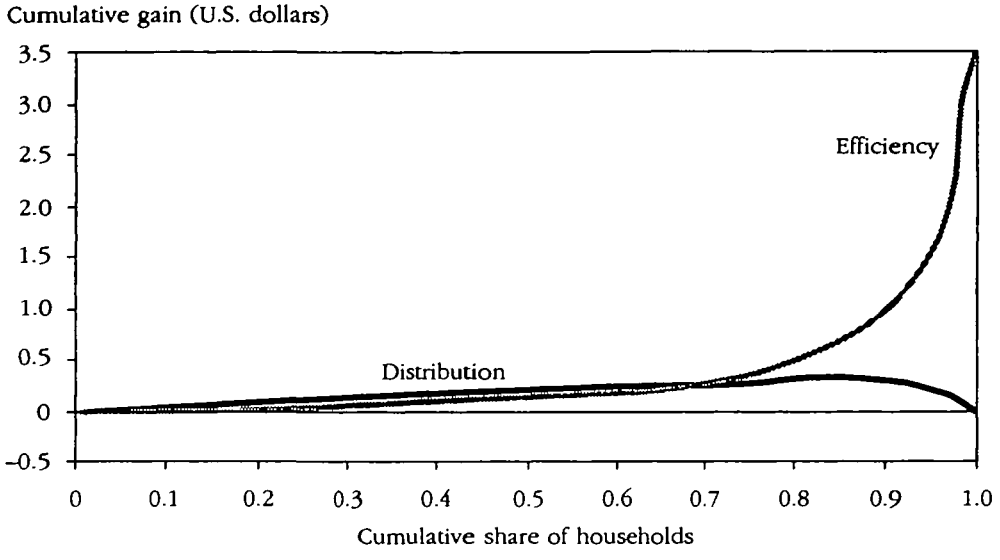
- Dalton-improving reforms should not discriminate between regions or ethnic groups. The way to incorporate such a consideration is to impose the restriction that reforms must be Dalton-improving for each region or group.

Table 3. *Structure of Revenue-Neutral Dalton-Improving Reforms, Indonesia*
(U.S. dollars)

Reform	*Kerosene*	*Electricity*[a]	*Gasoline*[a]
Distribution (D)	−1.0	1.035	−0.035
Efficiency (E)	−1.0	3.260	−2.260

a. The change in the tax on the commodity for each one-dollar reduction in the tax on kerosene.
Source: Authors' calculations.

Figure 5. *Cumulative Gain of Two Extreme Dalton-Improving Reforms, Indonesia*



Note: Cumulative share of households is from the lowest- to the highest-income.
Source: Authors' calculations.

- The set of Dalton-improving reforms was derived under the assumption that expenditure per capita represents the ranking of economic well-being. Most economists will probably agree that family size can affect economic well-being, but there may be disagreement about its quantitative effect. The same argument can be raised with respect to a rural/urban distinction. Mayshar and Yitzhaki (forthcoming) show how to incorporate such considerations.
- An additional consideration is popular support. To satisfy both the economist and the politician we can, for example, search for Dalton-improving reforms that maximize the number of beneficiaries. The major problem in incorporating such a constraint is that, unlike the search for a Dalton-improving reform, which can be carried out with tabulated data, the search for a majority requires that the whole sample be examined. Needless to say, this constraint is much less binding in the era of modern computers.

VIII. Sensitivity Analysis

Most of the analysis in this article was carried out without any parameterization: no assumptions were made on the curvature of the Engel curves of the

commodities, and the assumptions concerning the social welfare function are pretty mild. The only parameters that are derived from rigorous modeling efforts are the marginal efficiency costs of public funds. But revenue estimates are routinely performed by almost all treasury departments, and they are necessary inputs into the tax reform process. Because revenue estimates are based on a blend of complex modeling and intuition, performing traditional statistical testing is often difficult, especially if the number of parameters is large.

One way of investigating the robustness of our conclusions is to perform a sensitivity analysis on our revenue estimates by changing the marginal efficiency cost of public funds and observing the effect on the set of Dalton-improving reforms. Since our results depend only on the ratios of these costs, any multiplicative bias in the estimates should not affect the conclusions. Also, it is clear that if the marginal efficiency cost of public funds of kerosene is reduced and the costs of electricity and gasoline are increased, there will be no qualitative change in the conclusions.

Because of its magnitude, the marginal efficiency cost of public funds for gasoline (2.7) (see table 2) is most suspect. To evaluate how strongly it shapes the results, we reduced it gradually to see if our conclusions changed qualitatively. Small changes did not change the results qualitatively, and even a reduction by 40 percent (from 2.7 to 1.62) still produced a Dalton-improving reform (−1.0 for kerosene, −1.67 for gasoline, +2.66 for electricity) and an overall efficiency gain of 0.75 dollar (these results are not shown). Changing the marginal efficiency cost of public funds of electricity by 10 percent upward and downward also failed to produce any qualitative change.

An explanation for the robustness of the results can be found by reexamining figures 2 and 3. Figure 2 shows that if the marginal efficiency costs of public funds are equal, there can be three types of Dalton-improving reforms: subsidize kerosene and tax electricity, subsidize kerosene and tax gasoline, or subsidize electricity and tax gasoline. Hence, if the marginal efficiency cost of public funds of electricity is lower than that of kerosene, the Dalton-improving reform will consist of subsidizing kerosene and taxing electricity. Therefore the conclusion that we should increase the subsidy to kerosene will be unaffected even if the marginal efficiency costs of public funds of electricity and gasoline are lowered to equal that of kerosene. On the other hand, it is worthwhile to reduce the subsidy to gasoline because of its high marginal efficiency cost of public funds. This result will not be affected as long as this cost continues to be higher than that of electricity. If the marginal efficiency cost of public funds of gasoline is below that of electricity, then the Dalton-improving reform would call for an increase in the tax on gasoline and subsidizing electricity. But for this result to occur, the marginal efficiency cost of public funds for electricity must rise from 1.1 to above 2.7.

Finally, it should be noted that Dalton-improving reforms are not sensitive to the number of instruments considered. That is, provided that the estimates of the marginal efficiency cost of public funds are not affected, the reforms found

Table 4. *Nonneutral Dalton-Improving Reforms, Indonesia*
(U.S. dollars)

Reform	*Revenue*[a]	*Kerosene*	*Electricity*[b]	*Gasoline*[b]
Distribution, D.5	0.50	−1.0	1.91	−0.41
Efficiency, E.5	0.50	−1.0	2.88	−1.38
Successful reform, R.7S	0.70	−1.0	2.38	−0.68
Failed reform, R.75F	0.75	−1.0	2.56	−0.81

a. The revenue requirement of the reform. Values are for each one-dollar reduction in the tax on kerosene.
b. The change in the tax on the commodity for each one-dollar reduction in the tax on kerosene.
Source: Authors' calculations.

to be Dalton-improving will continue to be so even if we change additional taxes and subsidies. Additional instruments can only increase the Dalton-efficient set, they cannot eliminate a solution from the feasible set.

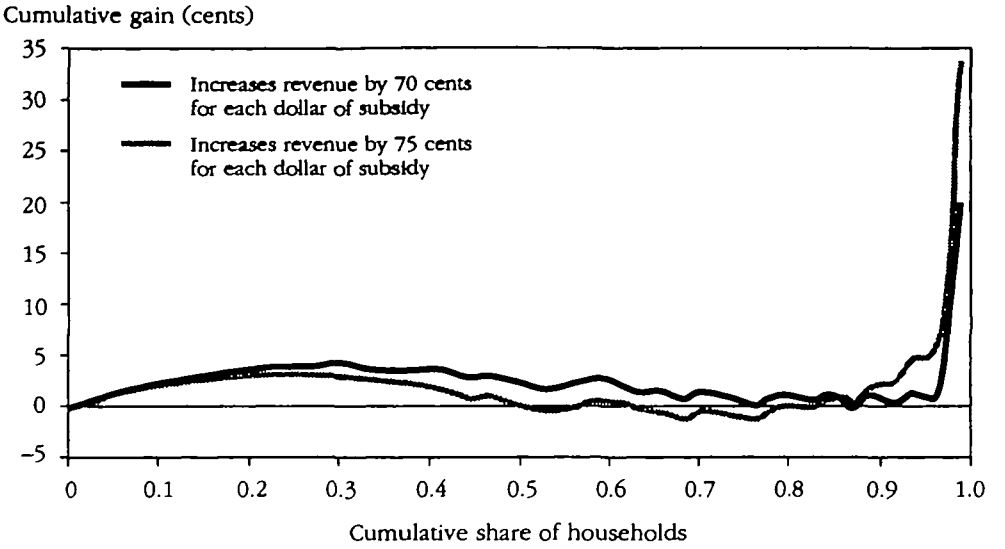
IX. Nonneutral Reforms

To analyze nonneutral reforms, we must know the public's willingness to pay for the public goods produced by the government. Since some of the Dalton-improving reforms brought about an efficiency gain, the question arises as to whether it is possible to split the gain between the public and the government, subject to the extreme and unrealistic assumption that the government "wastes" its share. To search for such a reform, we have to change the revenue constraint (equation 6) so that $dR \geq c$, where c is a constant greater than zero.

We consider four reforms (table 4). The first two reforms, D.5 and E.5, are the extreme Dalton-improving reforms, subject to the constraint that the reform must raise 50 cents on every dollar of subsidy to kerosene. Since kerosene is chosen to be the numeraire, the reforms are normalized according to its subsidy; however, as a result, each reform raises a different amount of tax revenue. Alternatively, the amount of additional taxes collected could be chosen as the numeraire, but in this case the numeraire would have to be adjusted after each calculation. Similar to the reforms reported in table 3, reform D.5 increases the income of the poor, and reform E.5 primarily increases efficiency. Comparing table 3 with table 4 reveals that the set of nonneutral Dalton-improving reforms that raise revenue by 50 cents to each dollar of subsidy is contained within the set of Dalton-improving reforms that are revenue neutral. The range of change in electricity taxation has declined from 1.035–3.26 dollars to 1.91–2.88 dollars, which may indicate that the distributionally oriented reforms are more sensitive to revenue neutrality than reforms concerned with efficiency.

Given the possibility of raising revenue and satisfying the Dalton criterion, we are tempted to ask how much more revenue can be extracted. From the last two rows of table 4, we see that when the revenue requirement was raised to 70 cents, we could still find Dalton-improving reforms. Reform R.7S reports the changes in taxes that are required. However, an attempt to raise 75 cents failed

Figure 6. *Cumulative Gain of Revenue-Raising Reforms, Indonesia*



Note The lines show the cumulative gains to the public for reforms raising $0.70 and $0.75 in revenue for each dollar of subsidy. Cumulative share of households is from the lowest- to the highest-income.

Source: Authors' calculations.

to find a Dalton-improving reform—reform R.75F is the best reform that could be found, although it is not a Dalton-improving reform. Examining the cumulative gains to the public (ignoring additional revenue) of reforms R.7S and R.75F (figure 6), we see that reform R.7S continues to generate a cumulative gain of 35 cents, mainly for the top three deciles, a gain of 5 cents for the lowest two deciles, and a loss of 5 cents to the middle class. Although reform R.75F does generate 75 cents, it hurts the second to the sixth deciles (the cumulative gain curve is declining), while the rich still receive 30 cents.

X. Further Research and Conclusions

The sensitivity analysis carried out suggests that the recommended directions for tax reform are robust with respect to variation in the marginal efficiency costs of public funds. The question is whether these recommendations are sensitive to other assumptions.

We could argue, for example, against aggregating rural and urban populations because of concerns that urban and rural economic welfare are not comparable—a higher income may be needed in the city for households to reach the same level of economic well-being as in rural areas—or transfers between urban areas and rural areas (or the reverse) cannot be made for political reasons. These

Table 5. *Gini Income Elasticities*

Variable	*All*	*Urban*	*Rural*
Kerosene	0.59	0.21	0.55
Electricity	1.61	1.12	1.37
Gasoline	2.30	1.90	2.62

Note: Income elasticity is calculated with respect to expenditure; households are ordered according to expenditure per capita.
Source: Authors' calculations.

two concerns can be handled by imposing additional constraints on the Dalton-improving reform (Mayshar and Yitzhaki forthcoming).

We can evaluate the sensitivity of our results to the aggregation of rural and urban households by calculating Gini income elasticities (table 5). There are significant differences in income elasticities (and hence in the shape of the Engel and concentration curves) between rural and urban populations. The overall income elasticity of kerosene and electricity is bigger than the income elasticity in either rural or urban areas, indicating that the Engel curve of the full population is steeper than the Engel curve for each subpopulation. However, the income elasticity of gasoline for the entire population falls between that for the urban and that for the rural. These elasticities suggest that the results can be affected by imposing a constraint on rural-to-urban cross-subsidization.

This article describes the search for Dalton-improving reforms. When the method is applied to the energy sector of Indonesia, which is characterized by high gasoline taxes and high kerosene subsidies, we find that efficiency concerns alone suggest that the distortionary gasoline tax and kerosene subsidy should both be lowered. But when distributional concerns are considered, we see that the given structure of energy taxes is more reasonable. Indeed, the analysis suggests that, given the structure of demand for different energy products, equity could be improved further by reducing the gasoline tax, increasing the subsidy to kerosene, and imposing a tax on electricity (to achieve revenue neutrality). These conclusions are robust to changes in the relevant parameters representing the Indonesian economy.

Appendix. The Computable General Equilibrium Model

The Indonesian CGE model used to derive the estimates of the marginal efficiency cost of public funds is one of a class of models that have been applied to issues of trade strategy, income distribution, and structural change in developing countries. Such models simulate the operation of a market system in which prices, wages, and the exchange rate vary in order to equate supply and demand for goods, labor, and foreign exchange. A variety of substitution mechanisms are specified among labor types, between capital and labor, between value added and intermediate inputs, between imports and domestic goods, and between

exports and domestic sales—all occurring in response to variations in relative prices.

The CGE model contains twenty-six productive sectors. The structure of the energy and environment sector includes seven separate fuel sectors (coal, diesel, fuel oil, gasoline, high-speed diesel oil, kerosene, and natural gas) and three others that are related to energy supply and demand (electricity and gas, liquefied natural gas, and oil). Of the remaining sectors, two are agricultural, three are services, and the others are industrial. There are seven primary factors of production (two types of agricultural labor, three types of industrial labor, capital, and land), four household categories, and three groups borrowing externally (the government, public enterprises, and the private sector), with separate external debt accounts for each. Labor supply in each category is assumed to be fixed. Investment is set equal to total savings, determined by applying fixed saving rates to household and government income. In keeping with the focus on energy, we expanded the modeling of energy supply and demand interactions. The model includes the possibility of extensive interfuel substitution and specification of more elaborate market-clearing mechanisms for the energy products in order to reflect the endogenous fuel taxes or subsidies created by the system of government-administered retail fuel prices.

Although there are a variety of different tax instruments in the model, the simulations carried out for this article involve changes only in the sectoral consumption tax levied on domestic consumption (including both domestically produced and imported goods). In each case the experiment involves raising the sectoral tax by 5 percentage points from its initial value. The static revenue impact is calculated as 5 percent of the base-period value of consumption. The equilibrium impact is the overall change in government revenue after the model is solved and all markets clear following the tax change. Although estimates of revenue change depend on the parameterization of the CGE model, what is important for the Dalton-improving calculations is the relative magnitudes of the marginal efficiency cost of public funds for each commodity. Given the CGE model structure, different plausible parameter choices are unlikely to affect the ranking or relative magnitudes of these costs.

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