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ESTIMATING THE DISTRIBUTION OF TAX BURDENS

A comparison of different approaches

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1. Introduction

The problem of tax-burden distribution is an illustration, par excellence, of the difficulties facing policy-oriented economists. On the one hand, it is evident that firm scientific judgment regarding the distribution of tax burden, or the distributional implications of alternative tax measures, is exceedingly difficult to come by. Approached in rigorous terms, the problem involves full-fledged general equilibrium analysis with all its difficulties. On the other hand, it is no less evident that distributional considerations are (and properly so) a prime factor in the formulation of tax policy. Policy makers *will* make assumptions regarding the burden distribution of various taxes and the question for the tax economist is whether or not to help in formulating them. Proceeding on the premise that even defective information is better than a random choice, economists have provided answers, based on rather simplified assumptions, and a methodology which falls far short of a genuine general equilibrium approach. These studies, several of which have appeared over the last three decades,[1] have been used widely for policy judgment and for assessing the quality of the tax structure in distributional terms.

The purpose of this paper is to compare the outcome of the simplifying

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[1]See, for example, Bishop (1953), Colm and Tarasov (1940), Musgrave et al. (1951), Musgrave et al. (1974), and Pechman and Okner (1974).

approach underlying these studies, with that of two possible general equilibrium models: a simple, two-sector analytical model designed to reflect a general equilibrium formulation of the problem, and a larger scale, empirical general equilibrium model recently developed by Fullerton, King, Shoven and Whalley[2] (hereafter referred to as FKSW). First, we point out the methodological assumptions of the traditional approach and note the hypotheses to be tested. In section 2 we present the analytical model and identify conditions which lead to rejecting these hypotheses. In section 3 we test the hypotheses for four different taxes in the framework of the empirical, general equilibrium model. Section 4 concludes the analysis by summarizing its salient points and discussing interpretations of the results. In an addendum, we examine the importance of price-change (uses) effects versus income (sources) effects in the context of the FKSW model.

We begin by briefly describing the major steps typically involved in the traditional approach to incidence studies as followed by Pechman, Musgrave and others (hereafter referred to as PM).[3] The objective of these studies is to allocate tax burdens by income groups. This is done for each tax by taking the total amount collected and imputing the resulting burden to households grouped by income classes. The total burden for each tax equals revenue collected.

The procedure is to *stipulate* the specific response of the economy to various taxes, based on theoretical analysis and market-structure specifications, and then to allocate the burden by income groups. Thus, it is stipulated that excise and sales taxes will be borne by the consumers of the taxed products and that the income tax is borne by the taxpayer. For some taxes alternative assumptions are explored. The burden distribution of the corporation tax may be examined assuming that the tax is borne by shareholders, that it falls on all capital income, or that the burden is spread to wage earners or to consumers of corporate products. Similarly, alternative assumptions may be examined for the property and payroll taxes.

This procedure has the advantage that it can be implemented readily, that the underlying assumptions are visible, and that the implications of alternative hypotheses can be appraised. It also has the weakness that the nature of incidence is stipulated rather than empirically derived. Furthermore, this stipulation is limited to only partial responses of the economy. Thus, taxes on products are taken to affect households from the uses side of their accounts only, the burden being distributed in line with the distribution of consumer expenditures. Further effects on factor prices, which may affect the

[2]For more detailed descriptions of the model, see Fullerton, Shoven and Whalley (1978) and Fullerton, King, Shoven and Whalley (1979).

[3]While using the abbreviation 'PM' for this general approach we recognize the contributions of the many other authors in this field. Also, various authors following this approach have used different incidence assumptions (see footnote 1).

position of households from the sources side, are disregarded, as are second-round effects on relative commodity prices. Thus, it is concluded that a sales tax on a luxury item will be progressive whereas one on a necessity will be regressive. Similarly, taxes on factor income such as the income tax are taken to affect household positions from the sources side only, the burden being distributed in line with earnings subject to tax. Further effects from the uses side, brought about by changes in relative prices, are disregarded.

To be sure, this procedure is not altogether arbitrary. The underlying argument is that the burden distribution of a tax which initially impacts from the sources side will be dominated by sources-side effects, because secondary effects operating from the uses side have no systematic relation to sources effects.[4] Thus, a progressive income tax is taken to be progressive. Similarly, it is postulated that the effects of a tax which initially impacts from the uses side will be dominated by uses-side effects, while further effects which result from the sources side due to changes in earnings will have no systematic relation to the uses side. The following discussion aims at testing these hypotheses.

In comparing the results of the PM methodology with those obtained from the FKSW model, we can ascertain the magnitude and direction of the change caused by allowing general equilibrium interrelationships. At the same time, we do not mean to imply that the model's results do indeed provide the 'true' answers. The model represents a first step in reproducing these real world effects, but by necessity, it employs simplifying assumptions of its own. This being the case, we attempt to gain further insights into the interaction of several key variables in terms of a simple, two-sector analytical model.

2. The analytical model

Since Harberger's (1962) pioneering work, several authors have developed general equilibrium models to analyze the effects of taxation.[5] Their contributions are surveyed in McLure (1975), and a particularly simple illustration is given by McLure and Thirsk (1975). Our model is essentially based on theirs. However, as with most writers in this field they focus on the general equilibrium effects of a tax on resource allocation and the functional distribution of income. Since we are concerned with the allocation of tax

[4]More precisely, the PM considers *either* uses effects only or sources effects only. Whether a particular tax is considered as having uses or sources effects depends on market structure assumptions. For instance, if markets are competitive, an employer payroll tax is treated in terms of its sources effects on wage income; if markets are imperfect so that the tax is added to product price, the PM analysis considers its uses effects on consumers of labor-intensive products.

[5]A similar analysis was developed earlier by Meade (1955) in the context of tariffs and international trade.

burden between individuals, we extend the McLure and Thirsk model to include two consumers with different endowments of each factor. Our model is structured to investigate the impact of a tax allowing for all general equilibrium effects. The purpose is to identify the strategic variables which determine the outcome. We consider a selective sales tax in this illustration, although the model can also be used to illustrate the effect of other taxes.

2.1. Description of the model

Since the two-sector model is familiar to most readers, we treat it very briefly here. Cobb–Douglas assumptions are made in order explicitly to solve for large tax changes. We consider an economy with two goods (X, Y) each of which is produced by a Cobb–Douglas production function, using only capital and labor, which are available in fixed total supply, K and L:

$$X = K_X^{\alpha} L_X^{1-\alpha}, \tag{1}$$

$$Y = K_Y^{\beta} L_Y^{1-\beta}, \qquad \alpha, \beta > 0. \tag{2}$$

There are two consumers (A, B) who derive utility by consuming goods X and Y in the Cobb–Douglas utility functions

$$U_A(X_A, Y_A) = X_A^{\gamma} Y_A^{1-\gamma}, \tag{3}$$

$$U_B(X_B, Y_B) = X_B^{\delta} Y_B^{1-\delta}, \qquad \gamma, \delta > 0. \tag{4}$$

Each consumer makes his purchasing decision by maximizing his utility subject to a budget constraint derived from his endowments of capital and labor. If we let I^A be consumer A's income; R, W the price of capital and labor, respectively, and λ, μ his share of the economy's capital and labor supplies, then

$$I_A = \lambda RK + \mu WL \tag{5}$$

Because this economy has only two consumers,

$$I_B = (1-\lambda)RK + (1-\mu)WL \tag{6}$$

Throughout the analysis we assume all agents are price-takers, producers maximize profit, consumers maximize utility, and all factors are mobile across sectors. Initially, there are no taxes in the system.

2.2. Equilibrium with a sales tax

We assume the economy is initially at an equilibrium with quantities normalized so that all prices are unity. We now impose a tax t on sales of good X. In order to keep the analysis as simple as possible, we assume, as do McLure and Thirsk (1975), that the government spends the tax revenue to exactly replace the loss in private demand in each sector from tax-induced income losses.[6] That is, nominal national income is constant before and after the imposition of the tax. Thus, if we denote with primes the prices and quantities in the new, cum-tax equilibrium, we have

$$P'_X X' = P_X X = X; \qquad P'_Y Y' = P_Y Y = Y. \tag{7}$$

But, from our Cobb–Douglas assumptions we know that factor payments command a constant share of net revenue in each industry. In other words,

$$R'K'_X = \alpha(1-t)P'_X X' = \alpha(1-t)X = (1-t)K_X \tag{8}$$

and

$$R'K'_Y = \beta P'_Y Y' = K_Y. \tag{9}$$

Note that P'_X denotes the new gross-of-tax price of X. We now have an expression for R', the new net rental price for capital services, from (8) and (9) and the fixed factor supply assumption $(K'_X + K'_Y = K)$:

$$R' = \frac{(1-t)K_X + K_Y}{K}. \tag{10}$$

Similarly, it can be shown that

$$W' = \frac{(1-t)L_X + L_Y}{L}. \tag{11}$$

In the same way one can solve for all the new quantities, prices, and incomes. For brevity, we only state the latter two:

$$P'_X = \frac{R'^{\alpha} W'^{1-\alpha}}{1-t}, \tag{12}$$

[6]This procedure ignores the excess burden of the tax, so that the sum of net gains and losses to consumers equals the yield of the tax.

$$P'_Y = R'^{\beta} W'^{1-\beta}, \tag{13}$$

$$\begin{aligned} I'_A &= \lambda R'K + \mu W'L \\ &= I_A - t(\lambda K_X + \mu L_X L_X), \end{aligned} \tag{14}$$

$$I'_B = I_B - t[(1-\lambda)K_X + (1-\mu)L_X]. \tag{15}$$

It can be shown that this new equilibrium satisfies certain conditions which appeal to intuition:

(1) If the tax is imposed on a capital-intensive commodity, the price of capital falls relative to the price of labor. That is, $R'/W' < 1$. By 'capital intensive', we mean that the taxed industry's capital labor ratio (K_X/L_X) exceeds the economy's (K/L).

(2) A tax on the capital-intensive commodity will result in a greater percentage loss in nominal income to the consumer with the more 'capital-intensive' factor endowment. For example, if $\lambda/\mu > (1-\lambda)/(1-\mu)$, A's endowment is more capital intensive than B's, so that

$$(I'_A - I_A/I_A < (I'_B - I_B)/I_B.$$

(3) The gross-of-tax price of the taxed commodity increases relative to the price of the untaxed commodity. In our notation $P'_X > P'_Y$.

From now on, therefore, we assume that X is the more capital-intensive commodity, and A is the consumer with the more capital-intensive endowment.

2.3. Testing the PM hypothesis

The PM estimate of the distribution of tax burden undoubtedly will not coincide with that of the general equilibrium approach, but we might ask whether the *ordering* of burdens to the groups of taxpayers can be reversed. The variables which determine the ordering will a fortiori determine relative income disparities.

As a commodity tax is imposed on X the PM method would compare the proportion of income spent on X by the two consumers to determine who bears the greater burden, defined as the ratio of tax paid to income. In our example this amounts to comparing γ and δ. Suppose $\delta > \gamma$, so that B is hurt more than A by the tax in the PM framework. We then look at the percentage change in real income from the general equilibrium calculation, and try to identify conditions under which the scales will tip the opposite way, with A registering a greater proportional loss in real income than B.

In general, if P'_A is some measure of the price level facing A in the new equilibrium (where P_A is unambiguously one), his percentage change in real income would be

$$\frac{I'_A/P'_A - I_A}{I_A}.$$

P'_A will depend on which market basket – the old or the new – is used for quantity weights. We compute both Laspeyres and Paasche versions of P'_A since they serve as bounds to the true measure of real income loss.

The Laspeyres price index (LPI) is defined as the change in prices weighted by old quantities. For A,

$$LPI_A = \gamma P'_X + (1-\gamma)P'_Y.$$

Similarly,

$$LPI_B = \delta P'_X + (1-\delta)P'_Y.$$

For A to suffer a greater real income loss than B, in proportional terms, it must be the case that

$$\frac{\dfrac{I'_A}{\gamma P'_X + (1-\gamma)P'_Y} - I_A}{I_A} < \frac{\dfrac{I'_B}{\delta P'_X + (1-\delta)P'_Y} - I_B}{I_B}. \tag{16}$$

Letting $I_{AX} = \lambda K_X + \mu L_X$ and $I_{BX} = (1-\lambda)K_X + (1-\mu)L_X$ stand for the incomes derived from industry X by A and B, respectively, we have, by rearranging, the inequality

$$\left(\frac{P'_X}{P'_Y} - 1\right)\left[\delta\left(1 - \frac{tI_{AX}}{I_A}\right) - \gamma\left(1 - \frac{tI_{BX}}{I_B}\right)\right] < t\frac{L_X}{L}\frac{\left(\dfrac{\lambda}{\mu} - \dfrac{1-\lambda}{1-\mu}\right)\left(\dfrac{K_X}{L_X} - \dfrac{K}{L}\right)}{\left(\dfrac{\lambda K}{\mu L} + 1\right)\left(\dfrac{1-\lambda}{1-\mu}\dfrac{K}{L} + 1\right)}. \tag{17}$$

Real income changes evaluated with the Paasche index lead to a similar inequality:

$$\left(1-\frac{P'_Y}{P'_X}\right)\left[\delta\left(1-\frac{tI_{BX}}{I_B}\right)-\gamma\left(1-\frac{tI_{AX}}{I_A}\right)\right]$$
$$<t\frac{L_X}{L}\frac{\left(\frac{\lambda}{\mu}-\frac{1-\lambda}{1-\mu}\right)\left(\frac{K_X}{L_X}-\frac{K}{L}\right)}{\left(\frac{\lambda K}{\mu L}+1\right)\left(\frac{1-\lambda}{1-\mu}\frac{K}{L}+1\right)}. \qquad (18)$$

These inequalities can now be interpreted. Consumer A, even though he spends a smaller fraction of his income on the taxed commodity, can be hurt more by the tax the greater are

$$\left(\frac{\lambda}{\mu}-\frac{1-\lambda}{1-\mu}\right)$$

and

$$\left(\frac{K_X}{L_X}-\frac{K}{L}\right);$$

that is, the more capital intensive are his endowment and the taxed industry. Furthermore, since $P'_X/P'_Y-1>0$, $\delta>\gamma$ and since $I_{AX}/I_A>I_{BX}/I_B$ from (14), (15), and condition 2, the left-hand side of (17) or (18) will be smaller the greater is the discrepancy between I_{AX}/I_A and I_{BX}/I_B. In other words, the more A relies on industry X for his income (relative to B), the more likely he is to lose from the tax.[7]

[7]Instead of comparing percentage changes in real income, the utility functions can be used to calculate compensating or equivalent variations. Because the functional forms imply constant marginal utility of income, the ratio of the equivalent variation to income in this case is equal to the percentage change in utility for each consumer. Reconsider the tax on X where B buys more of it ($\delta>\gamma$), X is the capital-intensive good, but A has capital-intensive income. Under what conditions is it true that

$$(U'_A-U_A)/U_A<(U'_B-U_B)/U_B \quad ?$$

After some manipulation it can be shown that this inequality is equivalent to

$$\frac{1-tI_{AX}/I_{AX}}{1-tI_{BX}/I_{BX}}<\left(\frac{1}{1-t}\right)^{(\gamma-\delta)}\left(\frac{1-tL_X/L}{1-tK_X/K}\right)^{(\gamma-\beta)(\delta-\gamma)}$$

Thus, the greater the discrepancy between I_{AX}/I_A and I_{BX}/I_B, the greater is the chance that the PM trend will be reversed. Turning to the right-hand side of the inequality, since $(\gamma-\delta)<0$ and $1/(1-t)>0$, the wider the gap between γ and δ, the more difficult it will be to reverse the PM calculations. However, the second term on the right-hand side gets larger as the capital intensity of industry X grows, so a high K_X/L_X (relative to K/L) could offset the PM pattern. Because PM use no utility functions, we proceed to a comparison between real income changes in the two approaches. See footnote 9 for a discussion of compensating and equivalent variations in the FKSW approach.

2.4. A numerical illustration

We can use the relationships developed above to study the relative importance of various parameters, such as capital–labor ratios, capital–labor intensities of endowments, etc. in reversing the pattern obtained by a PM calculation.

First, we estimate inequality (16) for a tax on housing, because this sector has by far the highest capital–labor ratio, a parameter which seems to be significant in altering the PM pattern. As data, we use the benchmark equilibrium of the FKSW model, collapsing their twelve consumer types into two, where A represents the six high income groups, and B is the six low income groups. We let X be the housing sector and Y an aggregate of all the other sectors. The FKSW data give the following values, where factor incomes equal quantities since units are defined as the amount which sells for \$1 net of taxes:

$$
\begin{array}{lll}
K_X = 56{,}832; & K = 181{,}974, & \\
L_X = \ \ 7{,}782; & L = 643{,}040, & \\
\alpha = 0.84; & \lambda = 0.81;^{8} & \gamma = 0.12, \\
\beta = 0.20; & \mu = 0.80;^{8} & \delta = 0.17.
\end{array}
$$

Now, inequality (16) is equivalent to

$$
\frac{1 - tI_{AX}/I_A}{1 - tI_{BX}/I_B} < \frac{\gamma(P'_X/P'_Y - 1)}{\delta(P'_X/P'_Y - 1)} \tag{19}
$$

since $I'_A - I_A = tI_{AX}$, etc.

From the above data,

$$
\begin{array}{ll}
I_{AX} = \lambda K_X + \mu L_X = 52{,}260; & I_{BX} = 12{,}345, \\
I_A = \lambda K + \mu L = 661{,}830; & I_B = 163{,}183.
\end{array}
$$

We consider the effect of a 50% tax on the gross price of X, or $t = 1/2$.

Thus, the left-hand side of (19) is 0.998. To calculate the right-hand side, we first estimate the new price ratio P'_X/P'_Y from eqs. (10)–(13). This value is 1.7, so the right-hand side of (19) is 0.965. Thus, even for the industry with

[8]Our model has no transfers whereas the FKSW model, and therefore its data, contain transfer payments. In calculating the capital and labor intensities of consumers' endowments, we treat transfer income as additional labor income. The surprising similarity of these capital–labor ratios is due to the high proportion of retired individuals in low-income groups.

the highest capital–labor ratio, the general equilibrium effects do not reverse the burden distribution pattern given by a PM or partial equilibrium calculation. On the other hand, the factor intensities of the two consumers' endowments were nearly equal which may explain the nonreversal. It is possible that more divergent parameters, on both sources and uses sides, could lead to results which conflict with the PM calculations. Sensitivity analysis shows that changing the endowments λ and μ to 0.9 and 0.7, respectively, still leaves the general equilibrium ordering the same as that obtained under partial equilibrium analysis. Increasing the capital–labor ratio of the taxed industry may lead to reversal, but the ratio used in the illustration is already quite high.

2.5. Conclusion

It goes without saying that this two-sector two-consumer model is a highly simplified view of the world. For one thing, changes in A's and B's relative positions hide further changes that occur within the two halves of the distribution. For another, using only two sectors and two factors over-simplifies the process of substitution which affects both sources and uses sides. Furthermore, the potential advantages of the general equilibrium over the PM approach are not properly tested by asking whether the *orderings* can be reversed, since policy decisions must consider *magnitudes* and not only directions of change. Nevertheless, our formulation has the virtue of helping to identify the parameters which offset the partial equilibrium pattern. For instance, the capital–labor ratio of the taxed industry plays an important role because it affects both sides of inequality (19); the capital-intensity of a consumer's factor endowments, on the other hand, appears only on the left-hand side. Finally, we have here considered only a sales or product tax. A similar analysis may be performed for an income tax or a factor tax.

3. Comparisons with the empirical model

3.1. An outline of the FKSW model

The empirical model developed by Fullerton, King, Shoven and Whalley uses 1973 data from the National Income Accounts, the Consumer Expenditure Survey, and the Treasury Department's merged tax file. The solution procedure employed is Merrill's algorithm similar to the well documented Scarf (1973) technique. We present here only a brief sketch of the model, a full description of which can be found elsewhere [see Fullerton et al. (1978, 1979)].

There are 19 industries that use capital and labor in constant elasticity of substitution production functions and also use the outputs of other industries as intermediate inputs through an input/output matrix with fixed coefficients. Each of these 19 producer goods are used directly by government, by foreign traders, and for investment goods, but indirectly for consumption through a fixed coefficient *G* matrix of transition into 16 consumer goods with suitable definitions for consumer demands. There are 12 consumer groups, differentiated by income class, each with an initial endowment of capital and labor and each with a set of preferences over the 16 consumer goods. Government collects taxes on many of these transactions and uses the revenue in a balanced budget to purchase producer goods via Cobb–Douglas demand functions, and to make direct transfer payments to consumers.

Through their interaction, these utility-maximizing consumers and profit-maximizing producers are assumed to reach a competitive equilibrium where all profits are zero and supply equals demand for each good and factor. Starting with data on endowments, budget patterns by income groups, taxes, and production parameters, we use the algorithm to calculate prices that satisfy these conditions. By first calculating an equilibrium that replicates our data and then altering some tax rule or parameter in order to calculate a simulated equilibrium, we can estimate the economic effects of such a change. Since the counter-factual equilibrium solution provides a complete set of prices and quantities, we can estimate the change in national income, utility or income changes for each group, and all new factor allocations among industries.[9]

While an economic model necessarily abstracts from reality, the FKSW model captures three features which are especially relevant to the analysis of tax incidence, namely variations in demand patterns across income groups, variations in capital–labor ratios in production, and variations in ratios of consumer factor endowments. On the other hand, in the neoclassical tradition the present version of the FKSW model assumes full employment of two homogeneous factors, each in fixed supply. It assumes perfectly competitive markets with no externalities, no quantity constraints, and no barriers to factor mobility.

To analyze a tax in this model, the institutional setting must be converted into model-equivalent terms. The corporation income tax and property tax,

[9]In comparing the PM and FKSW approaches, we use Laspeyres and Paasche measures of changes in real income. As an alternative measure of individual welfares the model calculates compensating variations, defined as the additional income at new prices required to attain old utility levels. We use only the real income changes, partly because they are easier to interpret, and partly because of complications in the model's utility functions: the individual chooses between future consumption and present consumption based on the current rate of return to savings. The utility level would be higher if the return to capital were higher and no other real changes occurred.

for example, are treated in combination as a tax on capital use by industry.[10] The assumption of perfectly competitive behavior then determines how these burdens are transmitted through the system. Finally, note that the model is essentially comparatively static, so that each equilibrium can be thought to represent a world where all adjustments have already taken place.[11] Moreover, by holding the capital and labor stocks fixed, growth effects are disregarded. Undoubtedly, because of these simplifying assumptions the model overlooks other aspects of the economy which have a bearing on the result. FKSW are currently extending their model to relax some of these assumptions.

Table 1 shows the industry and consumer good aggregations used in the model and their capital–labor ratios derived from the data. The two classifications are related by the fixed coefficient transition matrix. For example, the appliances commodity would require some machinery, some chemicals and rubber, some trade, and some transportation: its capital–labor ratio is a weighted average of the producer's capital–labor ratios.

Table 2 shows the income side for consumer groups by level of annual gross income. Column I displays the ratio of capital to labor income. Column II shows capital income as a share of total income (which includes earnings and transfers). The marginal tax rates, shown in column III, were averaged over individuals in each group from Treasury Department data. The high share of capital earnings to total earnings in the low-income brackets reflects a high proportion of retired persons who have no current labor income, but only capital income, largely in the form of imputed rents. The ratio of capital to labor income shown in column I is strongly U-shaped. This is less so in column II because transfers make up a high share of total incomes in the low brackets.

3.2. Experiments with the model

The experiments with the model involve the introduction of various taxes, where it is assumed that the revenue is returned to the taxpayers in the form of a transfer, made in proportion to after-tax income received prior to the

[10]While assuming that existing tax instruments can be modelled as ad valorem tax rates applied to sales of a good or factor, the FKSW model does not assume the incidence of the tax. For example, a tax on one use of capital might come to burden consumers or recipients of capital income depending on behavioral reactions described by the elasticity parameters.

[11]Although the data consider several types of capital income, it should be noted that the FKSW model aggregates these to one type of capital before calculations. One result of this procedure is that a tax on housing injures all capital, including the capital owned by the high-income consumer. Thus, the model does not consider the short-run effects on individuals who own capital specific to some industry, but instead concentrates on the long-run equilibrium effects, after capital has adjusted to the hypothetical tax, and earns the same return in all industries.

Table 1

Classification of industries and consumer goods, with capital–labor ratios.

Industry I	K/L ratio II	Consumer goods III	K/L ratio IV
1. Agriculture, forestry, fisheries	1.893	1. Food	0.125
2. Mining	0.241	2. Alcoholic beverages	0.077
3. Crude petroleum and gas	0.987	3. Tobacco	0.077
4. Construction	0.020	4. Utilities	0.203
5. Food and tobacco	0.107	5. Housing	5.354
6. Textiles, apparel, leather	0.062	6. Furnishings	0.106
7. Paper and printing	0.143	7. Appliances	0.095
8. Petroleum refining	2.922	8. Clothing and jewelry	0.070
9. Chemicals and rubber	0.202	9. Transportation	0.239
10. Lumber, furniture, stone	0.243	10. Motor vehicles	0.154
11. Metals, machinery and misc.	0.118	11. Services	0.116
12. Transportation equipment	0.012	12. Financial services	0.233
13. Motor vehicles	0.322	13. Recreation, reading, and misc.	0.122
14. Transportation, communications, utilities	0.224	14. Nondurable household items	0.107
15. Trade	0.075	15. Gas and other fuel	0.379
16. Finance and insurance	0.239	16. Savings	0.105
17. Real estate	7.303		
18. Services	0.113		
19. Government enterprises	0.515		
Total	0.283[a]	Total	0.272[a]

[a]Total K/L ratios differ because some of the producer goods are not used for consumption, and because consumers own some capital that is used by government and not by industry. A unit of each factor is defined as that which sells for one dollar net of factor taxes but gross of personal income taxes.

Table 2

Classification of consumer groups, capital–labor ratios, and marginal tax rates.

Consumer groups by \$ thousand of AGI	Ratio of capital to labor income I	Capital share of total income[a] II	Marginal tax rate III
1. 0–3,000	0.708	0.23	0.0100
2. 3–4,000	0.436	0.19	0.0608
3. 4–5,000	0.293	0.16	0.1019
4. 5–6,000	0.263	0.17	0.1228
5. 6–7,000	0.230	0.16	0.1346
6. 7–8,000	0.193	0.15	0.1570
7. 8–10,000	0.159	0.13	0.1813
8. 10–12,000	0.159	0.14	0.2078
9. 12–15,000	0.137	0.13	0.2215
10. 15–20,000	0.143	0.14	0.2618
11. 20–25,000	0.180	0.16	0.2897
12. 25+	0.549	0.43	0.4067
Total	0.233	0.20	

[a]'Total income' includes transfers, labor, and capital incomes. Capital income for each consumer group includes the sum of their interest, dividend and rent receipts, realized capital gains, some unincorporated income, and imputed net rent of owner-occupied homes.

change. The transfer is treated as nontaxable. Thus viewed, the experiments may be seen to measure budget incidence, i.e. the combined effects of a tax and expenditure change. Alternatively, the experiments may be viewed as combining the various tax increases with corresponding equal yield and income tax reductions in proportion to after-tax income. Thus seen, the experiments may be taken to measure differential tax incidence.[12]

The model has been estimated for four experiments, including (1) a progressive increase in income tax, (2) a tax on housing services, (3) a tax on clothing and jewelry, and (4) a tax on gasoline.[13]

Within the categories used, housing is clearly the most capital-intensive consumer good, as seen in table 1, since it uses mostly the real estate industry's output. Clothing and jewelry is the most labor-intensive consumer good, but its K/L ratio is still higher than the minimum for producer goods since it is a weighted average of several of those goods. It includes mostly textiles, with the lowest K/L ratio. In table 3 we show the expenditure patterns on our three commodities by income group.[14] It can be seen that housing behaves much like a necessity, making up a relatively larger proportion of the low income consumer's budget. Clothing and jewelry behaves more like a luxury good. These characteristics help explain the choice of these commodities for an analysis of the product tax. Gasoline is

Table 3
Expenditures on housing, gas, and clothing and jewelry as a proportion of after-tax income for each consumer group.

Consumer group	Housing	Gasoline	Clothing and jewelry
1	0.22	0.029	0.054
2	0.20	0.028	0.062
3	0.18	0.032	0.059
4	0.17	0.030	0.067
5	0.15	0.032	0.064
6	0.15	0.034	0.067
7	0.14	0.033	0.067
8	0.14	0.033	0.070
9	0.13	0.034	0.068
10	0.12	0.031	0.072
11	0.12	0.024	0.073
12	0.10	0.019	0.067

[12]Under either interpretation, the government maintains enough tax revenue to purchase the same commodities as it did in the benchmark equilibrium, thus preventing a higher level of government purchases from interfering with the general equilibrium effects of the tax change alone.

[13]Other experiments involving factor taxes could also be undertaken.

[14]While our groupings are by gross income brackets, the consumption ratios relate to after-tax income.

also chosen since its characteristics are much closer to the average of all commodities.[15]

In determining the magnitudes of the tax changes for our experiments, it is useful for the approach taken in section 3.4 that the taxes yield more or less the same revenue prior to the proportional redistribution. However, to design a set of tax rates which, after allowing for general equilibrium adjustments, would raise precisely the same revenue, would require extensive simulation with the FKSW model. Instead, we use an approximation technique which employs the revenue raised by increasing the tax on gasoline to 100% as a benchmark. We determine tax rates on income and on various commodities needed to yield the same revenue, or $9,893 billion, assuming that expenditures on the commodities remain unchanged. The resulting levels of revenue obtained by applying these rates to the FKSW model, as shown in table 4, fail to equalize, but to economize on computation these rates were used in the subsequent analysis.[16]

Table 4 also shows the percentage change in the relative price of capital and the welfare gain or loss for each experiment. The latter is defined as the change in real national income, as measured by the geometric mean of the Paasche and Laspeyres measures. We would normally expect that a large 'distortionary' tax on only one commodity would result in a welfare loss, but only in a world with no other distortions. The natural advantage of this model is that all taxes are included, particularly taxes on the use of capital by industry. The corporate income tax represents a large distortionary tax on the use of capital by many industries other than the housing/real estate industry. A new high rate of tax on housing output is essentially a tax on capital in housing since this industry is so capital intensive. It tends to equalize the levels of capital tax rates across industries and cause a welfare

[15]It should be noted that these expenditure patterns reflect the use of cross section data and are thus based on annual, rather than lifetime, consumption behavior.

[16]This differential is troublesome only for the cross-experiment comparisons in section 3.4 since the PM incidence is estimated for the FKSW yield in the single experiment comparisons of section 3.3.

By its nature, the PM procedure's patterns are invariant to changes in the size of the tax rate, which of course is a highly questionable notion. It is interesting to note, though, that the pattern of the model's distributional results, even though it depends on the level of taxation, does not change significantly for variations in the magnitude of the tax. For example, the percentage changes in real, after-tax income (using a Laspeyres price index) for the twelve consumer groups from a 8.52% increase and a 100% increase in the housing tax are:

Consumer group	1	2	3	4	5	6	7	8	9	10	11	12
8.5% tax	−0.29	−0.16	−0.08	−0.09	−0.03	0	+0.03	+0.07	+0.13	+0.15	+0.14	0
100% tax	−6.6	−5.8	−5.3	−5.5	−5.1	−5	−4.7	−4.4	−3.8	−3.6	−3.5	−3.7

The welfare gain, however, does change significantly up from $500 to $3,340 million per year.

Table 4

Summary of the experiments.

	Existing tax I	Additional tax II	PM yield[a] III	FKSW yield[a] IV	FKSW change in return to capital V	Welfare gain[a,b] VI
Income tax	–	–	9,893	9,906	0.03 %	−4
Housing tax	0	8.52 %	9,893	7,699	−1.52 %	500
Clothing and jewelry tax	7.32 %	19.3 %	9,893	7,926	0.49 %	−194
Gasoline tax	29.51 %	70.49 %	9,893	5,752	−0.33 %	−228

[a]In millions of 1973 dollars.

[b]Welfare gain is defined as the geometric mean of Paasche and Laspeyres measures of the change in real national income.

gain in this second-best world. Taxes on the other commodities cause net distortions and welfare losses.

3.3. Comparison for single experiments

We now compare the results obtained under the model with those of the PM procedure. For this purpose, the revenues obtained from the model procedure as given in column IV of table 4 are allocated according to the PM-type approach for each tax increase, using the incidence assumptions as specified below.

3.3.1. Increase in income tax. The progressive increase in income tax is shown in table 5. In column I we show the increase in tax burden which

Table 5

Progressive increase in income tax.

	PM procedure		FKSW model
Consumer type	Tax paid I	Net tax II[a]	% real income change (Laspeyres and Paasche) III
1	−0.018	+1.02	+1.03
2	−0.15	+0.89	+0.89
3	−0.34	+0.69	+0.70
4	−0.45	+0.59	+0.59
5	−0.50	+0.53	+0.54
6	−0.65	+0.39	+0.39
7	−0.80	+0.24	+0.24
8	−0.99	+0.05	+0.05
9	−1.07	−0.03	−0.03
10	−1.31	−0.27	−0.27
11	−1.38	−0.34	−0.34
12	−1.47	−0.43	−0.42

All figures are percentages of real after-tax income.
[a]Rebate calculated as 1.04% of each group's original after-tax income.

arises under the PM procedure which, in this case, simply allocates the burden in line with statutory liabilities. This result is not comparable with that of the model because the latter shows the net outcome of the combined tax-transfer measure. To permit comparability, we allocate the transfer in proportion to disposable income, prior to the change thereby obtaining column II, with the difference between I and II equal to 1.04% throughout the income scale. (This figure of 1.04% represents the ratio of the tax revenue to disposable personal income. Since the revenues are rebated according to each consumer group's disposable income, the transfers amount to 1.04% across the board.) Column II may then be compared with column III, showing the model estimate of the resulting change in real income. Note that column II necessarily contains plus and minus items, since the underlying amounts (net taxes or net transfers) add to zero. This need not be the case for the model results since the stipulated changes in tax structures may raise or lower the efficiency cost of the system and hence lower or raise the level of real income.

As will be seen by comparing columns II and III, the results under the two procedures are almost identical. The burden distribution of the income tax in the model appears to be dominated entirely by the distribution of the initial liabilities and transfer claims. Secondary effects due to changes in earnings and relative prices seem negligible.

One might expect a 'pro-poor' shift in disposable income to increase the relative price of necessities versus luxuries in the short run, counteracting on the uses side the 'pro-poor' effect of the sources side. The FKSW model includes constant returns to scale, however, so that long-run higher prices of necessities can only occur if these goods are produced by a process which is particularly intensive in one factor, and the price of that factor rises.[17] This effect is not noticeable, so the results of the model sustain the PM procedure of allocating a change in income tax liabilities to the statutory base.

3.3.2. Tax on housing. The patterns become more divergent, however, as we turn to the other taxes. Table 6 shows the comparison for a tax on housing. A first relevant characteristic of housing services is the high capital–labor ratio in the provision of such services. The distributional significance of this is shown in table 2, indicating that the share of capital income follows a 'U-shaped' pattern. Another, as shown in table 3, is the regressive consumption pattern, with housing expenditures declining as a share of income when moving up the income scale.

The results under the PM procedure are shown in columns I and II of table 6. In column I the tax is viewed as falling on housing consumption and is allocated accordingly. In column II the tax is viewed as a selective tax on capital income which, in the process of adjustment, comes to be distributed and hence is allocated in line with capital income from all sources. The burden distribution in column I is thus regressive, while that in column II is U-shaped. These are the two extreme alternative incidence assumptions generally used in the PM procedure. Columns III and IV give corresponding

[17]In fact, low-income groups tend to purchase goods that are somewhat more capital intensive, and an increase in their disposable income tends to raise the price of capital and therefore the prices of these commodities. The higher price of capital also has second-order effects on the sources side of income. Note from table 4, however, that this experiment changes R by a mere 0.03%. Without an effect on factor prices there can be no change in consumer prices. Hence, the sources side dominates.

Table 6

Tax on housing.

Consumer group	PM procedure: as consumer tax I	as capital tax II	I as net tax[a] III	II as net tax IV	FKSW: Laspeyres V	Paasche VI
1	−1.34	−0.93	−0.54	−0.13	−0.29	−0.19
2	−1.22	−0.77	−0.42	+0.03	−0.16	−0.07
3	−1.10	−0.65	−0.30	+0.15	−0.08	+0.01
4	−1.04	−0.64	−0.24	+0.16	−0.09	0
5	−0.92	−0.65	−0.12	+0.15	−0.03	+0.05
6	−0.92	−0.61	−0.12	+0.19	0	+0.07
7	−0.85	−0.53	−0.05	+0.27	+0.03	+0.11
8	−0.85	−0.57	−0.05	+0.23	+0.07	+0.14
9	−0.79	−0.55	+0.01	+0.27	+0.13	+0.20
10	−0.73	−0.57	+0.07	+0.23	+0.15	+0.21
11	−0.73	−0.65	+0.07	+0.15	+0.14	+0.21
12	−0.61	−1.75	+0.19	−0.95	0	+0.05

[a]Rebate: 0.8% of income. All figures are in percentage of real after-tax income.

results after adding back gains from the corresponding transfer, equal in this case to 0.8% of disposable income. Since the transfer distribution is proportional, the incidence, measured as the income elasticity of tax burden between any two points, becomes less regressive.

The results for the model include effects emerging from both the uses and the sources side. Over the lower half of the income scale both are regressive and mutually reinforcing, whereas over the upper half they work in opposite directions. The results are shown in column V for the Laspeyres and in column VI for the Paasche index. We note that the net effect of column VI is one of gain almost throughout the scale. This, in part, reflects the rise in total income because of the welfare gain from a housing tax, as described in the previous section. The 'true' income changes would presumably lie between the Paasche and Laspeyres measures, with losses to low income groups, gains to high income groups, and a net increase in the total.[18]

Comparing columns III and IV on one side and V on the other, it appears that the monotonically regressive (pro-rich) pattern of III is more similar to V than is that of IV. This suggests that the PM procedure, based on treating the housing tax as a consumption tax, is more in line with the FKSW result than treating it as a tax on capital income.

[18]The net gain comes about notwithstanding the fact that in designing the model, the transfer is made in lump sum form, and thus the level of taxes which can create efficiency costs is increasing.

3.3.3. Tax on clothing and jewelry. Clothing and jewelry reflects a commodity group with a capital–labor ratio well below the average and a rising consumption to income ratio when moving up the income scale. However, the category represents an aggregate of too many commodities to exhibit distinct luxury characteristics. Columns I and II of table 7 accordingly show a somewhat progressive burden distribution under the PM approach,

Table 7

Tax on clothing and jewelry.

Consumer group	PM procedure		FKSW	
	Tax paid I	Net tax[a] II	Laspeyres III	Paasche IV
1	−0.66	+0.17	+0.26	+0.41
2	−0.76	+0.07	+0.11	+0.28
3	−0.72	+0.11	+0.05	+0.21
4	−0.82	+0.01	−0.12	+0.07
5	−0.78	+0.05	−0.12	+0.05
6	−0.82	+0.01	−0.22	−0.04
7	−0.82	+0.01	−0.26	−0.08
8	−0.86	−0.03	−0.31	−0.12
9	−0.83	0	−0.31	−0.13
10	−0.88	−0.05	−0.35	−0.15
11	−0.89	−0.06	−0.34	−0.14
12	−0.82	+0.01	−0.15	−0.04

[a]Rebate: 0.83% real income. All figures are in percentages of real, after-tax income.

dampened somewhat in the net distribution of column II. A stronger progressive pattern is shown by both the Laspeyres index of column III, and by the Paasche index of column IV. The more highly progressive burden distribution derived from the model is in line with expectations. The low capital intensity of the taxed product, combined with the U-shaped pattern of the capital income share, should be expected to highlight the progressive nature of the real income change over the lower end of the scale. However, it should be expected to dampen it over the upper end, where the last two consumer groups also have higher than average capital intensity of income. This effect can be seen at the bottoms of columns III and IV.

3.3.4. Tax on gasoline. The relevant characteristics of gasoline are its approximately average capital–labor ratio in production and its bell-shaped distribution in consumption. The ratio of gasoline expenditures to income rises over the lower and falls over the upper part of the income scale. As shown in column I of table 8, this translates to a U-shaped burden allocation

Table 8

Tax on gasoline.

Consumer group	PM procedure		FKSW	
	Tax paid I	Net tax[a] II	Laspeyres III	Paasche IV
1	−0.59	+0.01	−0.55	+0.14
2	−0.57	+0.03	−0.55	+0.11
3	−0.66	−0.06	−0.82	−0.07
4	−0.61	−0.01	−0.84	−0.13
5	−0.66	−0.06	−1.01	−0.26
6	−0.70	−0.10	−1.22	−0.42
7	−0.68	−0.08	−1.21	−0.42
8	−0.68	−0.08	−1.22	−0.43
9	−0.70	−0.10	−1.31	−0.50
10	−0.64	−0.04	−1.09	−0.36
11	−0.59	+0.01	−0.95	−0.28
12	−0.39	+0.21	−0.50	−0.04

[a]Rebate: 0.6% real income. All figures are in percentage of real, after-tax income.

under the PM procedure since the table records estimated changes in real income from the tax. This pattern is repeated in the net burden distribution of column II. The model results, for both Laspeyres and Paasche, also show a U-shaped pattern, with both measures recording a decline in real income throughout the scale. As expected, because of the average K/L ratio in production, model results differ more by price index than they differ from the PM pattern. The pattern set by the initial impact on the uses side appears to dominate the complete result.

3.4. Cross experiment comparisons

Continuing our comparisons between the results obtained from the empirical model with those arrived at under the PM procedure, we now focus on the distribution of losses and gains which result as one tax is substituted for another. Assuming equal yields are obtained in all cases, this leaves transfers unchanged, and the incidence of any one replacement becomes independent of the transfer pattern. In this case only the tax difference would matter. Since, for previously noted reasons, the equal revenue criterion is not entirely met by our experiments, the transfer pattern continues to affect our outcome, but only to a minor degree.

Table 9 shows the substitution of the three commodity taxes for the income tax. Replacing a progressive increase in income tax by a tax on housing services may be expected to be regressive in its impact; this is shown in column I for the PM (using burden distribution by consumption) and the

Table 9

Comparison across experiments.

Consumer group	Progressive increase in income tax replaced by:								
	Housing tax			Clothing tax			Gas tax		
	PM[a]	FKSW		PM	FKSW		PM	FKSW	
		Laspeyres	Paasche		Laspeyres	Paasche		Laspeyres	Paasche
	I	II	III	IV	V	VI	VII	VIII	IX
1	−1.32	−1.32	−1.22	−0.64	−0.76	−0.61	−0.57	−1.86	−1.17
2	−1.07	−1.05	−0.96	−0.51	−0.78	−0.61	−0.42	−1.67	−1.01
3	−0.76	−0.77	−0.69	−0.38	−0.64	−0.48	−0.32	−1.69	−0.95
4	−0.59	−0.68	−0.59	−0.37	−0.71	−0.52	−0.15	−1.55	−0.85
5	−0.42	−0.57	−0.49	−0.28	−0.66	−0.49	−0.16	−1.65	−0.89
6	−0.32	−0.39	−0.32	−0.17	−0.61	−0.43	−0.09	−1.66	−0.86
7	−0.05	−0.20	−0.13	−0.02	−0.49	−0.31	+0.12	−1.47	−0.68
8	+0.14	+0.02	+0.09	+0.13	−0.36	−0.17	+0.31	−1.27	−0.49
9	+0.28	+0.16	+0.23	+0.24	−0.27	−0.09	+0.37	−1.24	−0.45
10	+0.48	+0.42	+0.48	+0.43	−0.08	+0.12	+0.65	−0.78	−0.05
11	+0.65	+0.48	+0.54	+0.49	−0.00	+0.20	+0.79	−0.56	+0.12
12	+0.86	+0.43	+0.47	+0.65	+0.28	+0.38	+1.04	+0.01	+0.42

[a]Housing tax is viewed as a consumption tax for the PM calculations. All figures are in percentage change in real, after-tax income.

columns II and III for the model results. The same also holds for the clothing and jewelry tax, although less so, reflecting the difference in patterns previously shown in table 7. Substitution of an increase in the gasoline tax, as may be expected, falls between the two preceding cases in its effect. Not surprisingly, the PM and FKSW results appear closer in these cross-experiment comparisons than with the single experiments.

4. Conclusion

In this paper we described a simple approximation method for estimating the distribution of tax burdens (the PM procedure), and compared its results with two alternative approaches. The first, an analytical two-sector general equilibrium model, helped identify the parameters which are crucial in causing the outcome of the PM procedure to diverge from the general equilibrium outcome. The second, a medium-scale, empirical model (the FKSW model) gave estimates of tax incidence which allow for general equilibrium effects and enabled a direct comparison with estimates of the PM procedure for four tax changes and three tax substitutions.

The PM and FKSW approaches give strikingly similar results for the case of the income tax. For the other cases we leave it to the reader to judge the degree of similarity. As may be expected, the similarity is greater for taxes on products whose capital–labor ratios are close to the average. Also, the cross experiments come out closer than the single experiments.

There remains the question of how similarity, or lack thereof, should be interpreted. Similarity may be taken to validate the PM procedure if it were assumed that the FKSW outcome is the 'true' one. It is evident, however, that the FKSW model still represents a highly simplified and overly aggregative picture. As the model is further refined, the results may well change and differ more from those of the PM procedure. For example, factor supplies might be rendered elastic. Also, if the model were more disaggregated, it would presumably show certain consumers with factor endowment ratios that were further from the average. This would cause stronger sources effects of a product tax. Similarly, consideration of heterogeneous factors, especially those factors specific to certain industries, would show strong short-run losses on the earnings side of a product tax.

Finally, we have compared the PM and FKSW approaches only with regard to estimating the burden distribution of a given tax revenue. We have not used any traditional or partial equilibrium procedures to estimate the revenue of a given tax rate, to estimate excess burdens, or to analyze other major taxes such as the payroll or corporate income tax.

5. Addendum on the separation of uses and sources effects

As noted earlier, the PM approach allocates product taxes in line with their initial impact on the uses side of the household account while allocating factor taxes on the sources side, either in line with their initial impact or as otherwise specified. With regard to product taxes, this neglects the resulting changes from the sources side, as well as further feedback effects from the uses side. With regard to factor taxes, it neglects resulting changes from the uses side as well as further feedback effects from the sources side. The underlying hypothesis is that initial uses and sources effects are controlling in determining incidence, while the neglected effects bear no systematic relationship to the pattern which emerges from these primary effects.

The general equilibrium approach of the FKSW model differs in that it is designed to account for total effects, primary as well as feedback, and covering both uses and sources side for all types of tax. Nevertheless, these overall results may be divided into two components: (1) sources effects which reflect changes in nominal income and (2) uses effects which reflect changes in price. This decomposition of the overall result is of interest because it indicates the relative importance of uses and sources characteristics of various households, as they bear on their burden under a particular tax. Moreover, it may throw further light on the reliability of the PM approach. However, a word of caution is warranted here. If it turned out that the FKSW approach shows the incidence of product taxes to be dominated by effects recorded on the uses side, while that of factor taxes is dominated from the sources side, this does not necessarily lend justification to the PM procedure of benign neglect. While some degree of support might be inferred, the answer is not at all clear-cut. This is the case because the PM concepts of sources and uses effects include primary effects only, while the sources and uses effects as recorded by the FKSW procedure are total, i.e. include playback effects.

The FKSW decomposition is also interesting because of its intuitive appeal. A general equilibrium result can be more easily comprehended by considering one part at a time. For any given consumer we define a real income change in the manner of section 2 for the Laspeyres and Paasche price indices. The proportional change in his real income is given by

$$\frac{I_1/PPI - I_0}{I_0} \quad \text{or} \quad \frac{I_1/LPI - I_0}{I_0}.$$

Note that the initial, nominal, after-tax income I_0 is equal to $\sum Q_0 P_0$, the sum of original expenditure at original cum-tax prices, and final after tax income I_1 is equal to $\sum Q_1 P_1$.[19] Since the proportional change under the

[19] Savings in the FKSW model are fed through directly to investment purchases. Thus I_1 is the numerator of the PPI, and I_0 is the denominator of the LPI.

Laspeyres measure is equivalent to $(I_1 - I_0 \cdot LPI)/(I_0 \cdot LPI)$, we have the operational relationships of table 10 for the numerators of these bounds. By either index, the uses and sources sides sum to the total change in real after-tax income. Heuristically, the sources side is the change in nominal income,

Table 10

Operational definitions of the uses side, sources side, and total change in real income.

Index	Total effect: change in real after-tax income	Sources side: from changes in factor prices and income taxes	Uses side: from changes in gross of tax expenditure prices
Laspeyres	$I' - I^0 \cdot LPI$	$I' - I^0$	$I^0 - I^0 \cdot LPI$
	$= \sum Q_1 P_1 - \sum Q_0 P_1$	$= \sum Q_1 P_1 - \sum Q_0 P_0$	$= \sum Q_0 P_0 - \sum Q_0 P_1$
Paasche	$I'/PPI - I^0$	$I' - I^0$	$I'/PPI - I'$
	$= \sum Q_1 P_0 - \sum Q_0 P_0$	$= \sum Q_1 P_1 - \sum Q_0 P_0$	$= \sum Q_1 P_0 - \sum Q_1 P_1$

the uses side is the effect of price changes (using either quantities as weights), and real income is the change in quantities (using either prices as weights).[20]

An unavoidable feature of this split between uses and sources effects is that it is not unique with respect to a shift from direct to indirect taxation. If an income tax were replaced by an equivalent tax on all consumption and investment commodities, these definitions would register a gain to the sources side and a loss to the uses side. The important aspect of this division, however, is the relative change accruing to different consumers. For brevity, only the Laspeyres calculations of the FKSW model are shown in table 11.

(1) The progressive change in the income tax appears to concentrate its impact on the sources side. The magnitudes of the uses (price change) effects are almost negligible. However, the directions of the changes displayed by the two effects are interesting.

The price change effect alone is uniformly regressive, since prices of capital-intensive products, including many necessities, have risen. The net effect on real after-tax incomes is clearly progressive, but certainly less progressive

[20]As an index for real income, it is well known that the Laspeyres is a lower bound since it understates gains and overstates losses, and Paasche is an upper bound since it overstates gains and understates losses. This can be seen in table 10 where the Laspeyres change, $\sum Q_1 P_1 - \sum Q_0 P_1$, puts a lower weight ($P_1 < P_0$) on the quantities that have increased ($Q_1 > Q_0$). It puts a higher weight ($P_1 > P_0$) on quantities that have decreased ($Q_1 < Q_0$). Similar arguments exist for the Paasche index. In this manner, we can also see how these indices represent bounds on the uses side alone. In table 10 the Laspeyres uses side is $\sum Q_0 P_0 - \sum Q_0 P_1$, where a greater weight ($Q_0 > Q_1$) is put on prices that have risen ($P_1 > P_0$), and a lower weight ($Q_0 < Q_1$) on prices that have fallen ($P_1 < P_0$).

Table 11

Uses, sources, and total effects of each tax change, in percentage terms, for Laspeyres index only.

Consumer no.	Laspeyres index	Real after-tax income	Price change effect	Income effect
A. Income tax change				
1	1.000	1.026	−0.009	1.035
2	1.000	0.889	−0.009	0.898
3	1.000	0.696	−0.009	0.705
4	1.000	0.590	−0.009	0.598
5	1.000	0.537	−0.008	0.546
6	1.000	0.389	−0.008	0.397
7	1.000	0.237	−0.008	0.245
8	1.000	0.048	−0.008	0.056
9	1.000	−0.033	−0.008	−0.024
10	1.000	−0.271	−0.008	−0.263
11	1.000	−0.338	−0.008	−0.330
12	1.000	−0.424	−0.007	−0.416
B. Tax on housing				
1	1.013	−0.292	−1.326	1.034
2	1.012	−0.164	−1.149	0.985
3	1.010	−0.077	−0.986	0.909
4	1.009	−0.085	−0.923	0.839
5	1.008	−0.031	−0.828	0.797
6	1.008	−0.002	−0.769	0.767
7	1.007	0.034	−0.744	0.778
8	1.007	0.066	−0.693	0.759
9	1.006	0.131	−0.619	0.750
10	1.006	0.147	−0.604	0.751
11	1.006	0.143	−0.567	0.710
12	1.004	0.003	−0.392	0.395
C. Tax on clothing and jewelry				
1	1.012	0.263	−1.201	1.464
2	1.014	0.113	−1.334	1.447
3	1.013	0.052	−1.286	1.338
4	1.014	−0.115	−1.424	1.309
5	1.014	−0.121	−1.364	1.243
6	1.014	−0.224	−1.416	1.191
7	1.014	−0.258	−1.426	1.167
8	1.015	−0.310	−1.479	1.168
9	1.015	−0.311	−1.439	1.128
10	1.015	−0.347	−1.515	1.167
11	1.016	−0.341	−1.534	1.193
12	1.014	−0.145	−1.415	1.270
D. Tax on gasoline				
1	1.020	−0.553	−1.914	1.362
2	1.019	−0.552	−1.817	1.265
3	1.021	−0.817	−2.071	1.255
4	1.020	−0.836	−1.944	1.108
5	1.021	−1.010	−2.096	1.086
6	1.023	−1.220	−2.255	1.035
7	1.023	−1.205	−2.209	1.003
8	1.023	−1.218	−2.203	0.986
9	1.023	−1.306	−2.263	0.958
10	1.021	−1.091	−2.043	0.951
11	1.019	−0.952	−1.876	0.925
12	1.013	−0.501	−1.251	0.750

than intended by the change in income tax rates. Commodity price changes serve to moderate the desired change in progressivity.

(2) The housing tax is fairly clear in its distributional effect. The uses side, or cum-tax expenditure price changes, are regressive as expected, since the proportion of income to housing is monotonically decreasing. The income or sources effect is progressive. We might have expected a U-shaped loss pattern since the relative price of capital falls 1.5 %, but the income tax rebates make all sources effects positive. The regressive uses side and progressive sources side combine to a net regressive change in real after tax income.

(3) The 'clothing and jewelry' aggregate good behaves most like a luxury good, as seen in table 3. The uses side of a tax would have progressive effects on consumer welfare, but again the sources side might counteract. Since this is the most labor-intensive product, a lower demand for clothing would imply a higher demand for capital relative to labor, and gains to capital-endowed individuals. As table 11 shows, price change effects are progressive as anticipated. Sources-side gains are mostly U-shaped, according to K/L ratios of endowments, and total effects are mostly progressive, but somewhat U-shaped. A major point, however, is that the expected price change effect is substantially altered by the income effect and the latter cannot be ignored.

(4) The consumption tax on gasoline would be expected to have the predicted (uses-side) effect since the capital–labor ratio in its production is close to the economy's ratio. As a result of the tax, the price of capital falls relative to that of labor by a miniscule 0.3 %. With almost no change in the factor price ratio, we expect no sources effect. Indeed, the only income effect to be noticed from table 11, part C, is from original transfers (social security, welfare), which make up a larger portion of the first consumer's income used for consumption. The model scales up these transfers by the price index to preserve their value in real terms, while factor incomes do not get scaled up. The total effect follows the price change pattern, where greater losses are made by middle income groups.

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