Chapter 7
Commitment to Equity Handbook
Estimating the Impact of Fiscal Policy on Inequality and Poverty
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Constructing Consumable Income: Including the Direct and Indirect Effects of Indirect Taxes and Subsidies

Jon Jellema and Gabriela Inchauste

1 Introduction

Chapter 6 by Higgins and Lustig described in detail how to construct income concepts.[1] In this chapter, we discuss how to construct "consumable income" when we want to take into account the indirect impact (that is, through their impact on input prices) of indirect taxes and subsidies. The chapter appendix "Tax Incidence Analysis with Intermediate Goods" provides a more detailed discussion of potential alternatives when estimating the indirect impact of indirect taxes and subsidies.

How--and from whom--a government collects and replenishes public revenues will make a significant difference to the income situation and the pattern of consumption expenditures among individuals and households participating in a nation's economy. For example, personal income tax schedules often have income exemptions and deductions specifically for larger families or credits for households whose wage and employment-based income are below a certain threshold. Such targeted tax expenditures[2] ease the burden of the personal income tax system on larger households and households where employment-related income is meager. Easing the burden on these types of households *may* mean that the poverty headcount rate as well as the net-of-tax income inequality are lower than either of these measures would be with, for example, a proportional or "flat tax" system.

Whether or not a revenue-collection instrument can be targeted also matters a great deal for inequality and impoverishment created by fiscal policy. Indirect taxes on consumption activity--customs duties, value-added taxes, excise taxes, sales taxes--are not usually administered flexibly; that is, all individuals with at least some market-based

[1] Higgins and Lustig (2018).
[2] "Tax expenditures" (from the point of view of the fiscal system) are the estimated revenue losses from special exclusions, exemptions, deductions, credits, deferrals, and preferential tax rates in tax law.

consumption activity pay indirect taxes.[3] Though unavoidable for individuals who participate in a nation's economy, indirect taxes are popular: the international CEQ database demonstrates that, for a 28-country average taken across low- and middle-income countries in Africa, the Middle East, Asia, and Latin America, indirect taxes provide approximately twice as much in public revenues as direct taxes. Accounting for indirect taxes (and subsidies) on consumption activity is therefore doubly important for fiscal incidence: not only does a typical revenue-collection scheme in a low- or middle-income country depend more on indirect taxes (so that the overall magnitude of indirect taxes in the economy will be greater than that of direct taxes), but most households also cannot avoid paying some part of the indirect tax burden.

1.1 Direct Impacts of Subsidies and Taxes

Taxes and subsidies on goods and services change final retail prices[4] and therefore directly affect household purchasing power and welfare. When consumption expenditure records are available in the household income and expenditure survey, the direct effects of indirect taxes or subsidies can be traced in a relatively straightforward way. This is typically done by first determining what proportion of total consumption expenditure is sales tax expenditure (or the proportion by which the value of consumption expenditure would increase in the absence of government subsidies), and then creating the "consumable income" concept by subtracting from disposable income the loss (gain) in purchasing power or welfare traceable to these taxes (subsidies).

However, a cross-section of consumption expenditure records (which is the least detailed microdata a CEQ assessment requires) does not provide evidence of what counterfactual expenditures would be in a world without taxes or subsidies. For example, this year's household budget survey would provide no insight into the distribution of expenditures last year when there was no sales tax on milk. Because a CEQ assessment estimates incomes before ("pre-fiscal") and after ("post-fiscal") the application of fiscal programs, the direct impact of an indirect tax or subsidy instrument is described as the change in income that results from the difference between the pattern of expenditures that would occur in the "pre-fiscal" setting, where there are no taxes or no subsidies, and the pattern of expenditure that exists in the current, actual "post-fiscal" world reflected in the consumption choices and expenditures recorded in the household survey.

In order to make such an estimate, we therefore need to employ assumptions that help us describe demand or expenditures in a counterfactual no-tax (or no-subsidy) world. Here we discuss two assumptions, inelastic demand and homothetic preferences, that are commonly employed in the welfare analysis of price changes[5] and that allow the CEQ

[3] As long as some part of an individual's consumption attracts at least one of the existing indirect taxes, then the individual will not avoid indirect taxes. An individual (or a household) subsisting exclusively on gifts and inter-household transfers and own-production/own-consumption will consume without directly paying any indirect taxes. See the appendix "Tax Incidence Analysis with Intermediate Goods" at the end of this chapter for a more detailed discussion of the actors and their activities which may attract taxes.
[4] See the appendix "Tax Incidence Analysis with Intermediate Goods" at the end of this chapter for a lengthier discussion of intermediate and final prices (including wages) in the presence of taxes.
[5] See Araar and Verme (2016) and their references.

analyst to specify expenditures in a counterfactual, "pre-fiscal" world in the absence of a model of consumer demand.[6]

1.2 Inelastic Demand

When demand for any taxed (or subsidized) good or service is inelastic, changes in prices do not lead to changes in quantity demanded. If demand is inelastic, then consumption in the pre-fiscal counterfactual would be equal to consumption recorded in the current, with-tax regime. If we assume demand is inelastic, we can then calculate the Paasche variation in the value of the consumption expenditure. The Paasche variation measures the value of consumption expenditure at two different points in time--call them initial and final--using prices from the final period. For our purposes, the Paasche variation measures the difference in the value of consumption expenditures in the "pre-fiscal" or "no-tax" counterfactual and the value of consumption expenditures in the "post-fiscal" or "with-tax" present reflected in the household survey.

Because we are assuming that demand is inelastic, we are implying that quantities demanded (of the taxed item in question) are constant across the "pre-fiscal" counterfactual and the "post-fiscal" present. This simplifying assumption allows us to generate the net-of-tax value of consumption expenditure by dividing the current value of consumption expenditure (*CE*) by one plus (minus) the relevant tax (subsidy) rate. That is,

(7-1) $$CE_{t-1} = CE_t / (1 + r),$$

where period $t - 1$ is the "pre-fiscal" period, t is the current period (where with-tax prices are reflected in the household survey), and r is the rate of taxation (expressed as a percent of the net-of-tax price). If we are interested in a subsidy, we can use the same formula as long as we remember that the rate r of taxation on a subsidized good must be negative. Figure 7-1, which is a simple demand schedule with quantity demanded, q, (x-axis) at each price, p (y-axis), shows that inelastic demand can be represented by a vertical demand schedule (where the quantity demanded does not change within a certain price range). The Paasche variation can be represented then by the difference (labeled "A" and shaded with hash marks) in the area of two rectangles: $P_t q_t$ and $P_{t-1} q_{t-1}$. Because q_t is equal to q_{t-1} (under the assumption of inelastic demand), the difference between the two rectangles simplifies to

(7-2) $$PV = q_t * P_t / (1 + r) * \text{abs}(r)$$

which is simply the current, "post-fiscal" value of consumption expenditures valued at "pre-fiscal" prices multiplied by the (absolute value) of the rate of taxation (subsidization). This is labeled "A" and shaded with hash marks in figure 7-1.

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[6] In other words, these assumptions can be used to generate the distribution (among households or individuals) of indirect tax burdens without requiring *more* information than the CEQ analyst already has at hand.

Figure 7-1: Paasche Variation in Consumption Expenditure

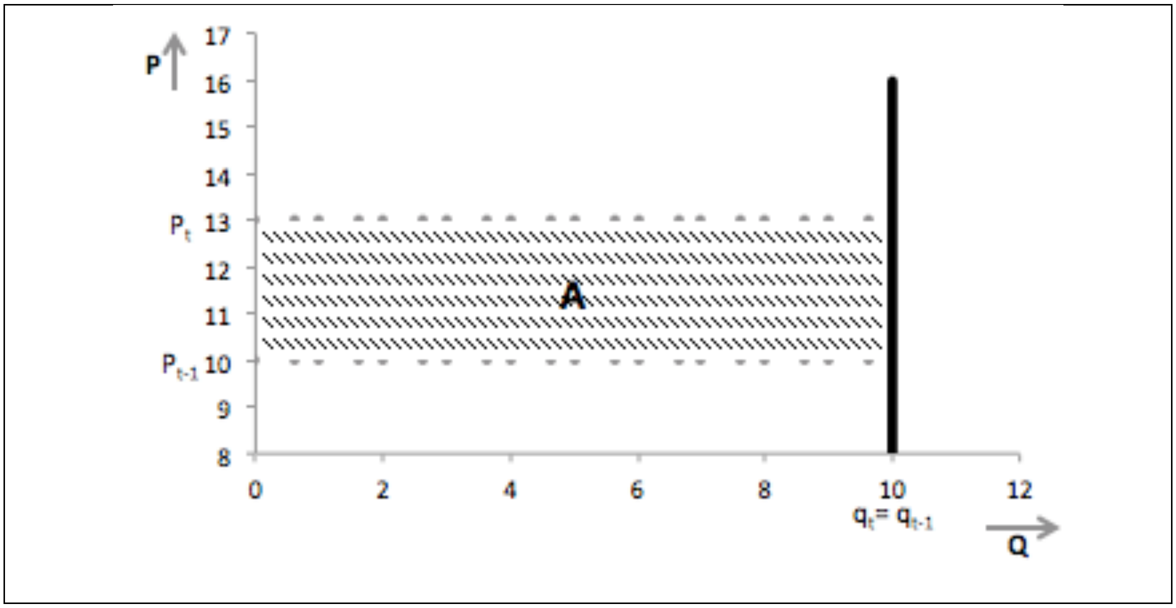

Figure 7-1 is a demand schedule with price on the y-axis and quantity demanded on the x-axis.

Figure 7-1 also makes clear that the Paasche variation is not a welfare measure: a consumer with inelastic demand is just as well-off (in welfare terms) at any price level as long as she is consuming the right quantity. Instead, we can think of the Paasche variation as the change in purchasing power experienced when the tax or subsidy is applied. That is, an individual will have to spend more (less) to acquire the same bundle of goods when taxes (subsidies) are imposed. This leaves less (more) room for purchases of other goods, meaning purchasing power declines (increases). It is the decrease (increase) in purchasing power (measured by the Paasche variation) that is subtracted from (added to) disposable income to arrive at consumable income.[7] Therefore, when a tax is imposed, we can place a negative sign in front of the first term in equation 7-2 to remind ourselves that an indirect tax *reduces* purchasing power relative to the counterfactual.

1.3 Homothetic Preferences

We can also make headway on the impact of taxes or subsidies in a cross-section of expenditure records if we model consumer demand as described by homothetic preferences. When consumers optimize utility (under a budget constraint) described by homothetic preferences, the ratios of goods demanded depend only on their relative prices and not on income or scale.[8] If consumer demand can be described by homothetic preferences,[9] then in the pre-fiscal counterfactual, quantities demanded are higher (lower) by exactly the amount of the current tax (subsidy): if a good is *currently* taxed at a 20-

[7] The decline (or increase, for a subsidy) in purchasing power can also be expressed as rate$_i$ * (consumption expenditure$_i$ / (1 + rate$_i$)), where *i* indexes the household-consumed good and "rate" refers to an indirect tax or subsidy rate. This formulation makes it easier to understand why we call this a "Paasche variation" welfare valuation.
[8] Varian (1992).
[9] And assuming there are no uncompensated cross-price elasticities.

percent rate, it is assumed that in a no-tax counterfactual, consumption would be 20 percent higher.[10]

Once we have a description of demand in the pre-fiscal counterfactual, we can proceed as before: compare the consumption expenditure necessary to achieve the optimal bundle of goods in the no-tax (no-subsidy) counterfactual with the consumption expenditure necessary to achieve the optimal bundle in the actual with-tax (with-subsidy) state. Figure 7-2 is a demand schedule under homothetic preferences that shows that the quantity demanded in the pre-fiscal hypothetical ($q_{t\text{-}1}$) is greater than the quantity demanded in the post-fiscal world by exactly the relative amount by which the price of the good P_t is higher in the post-fiscal world.

Figure 7-2: Consumer Surplus Variation under Homothetic Preferences

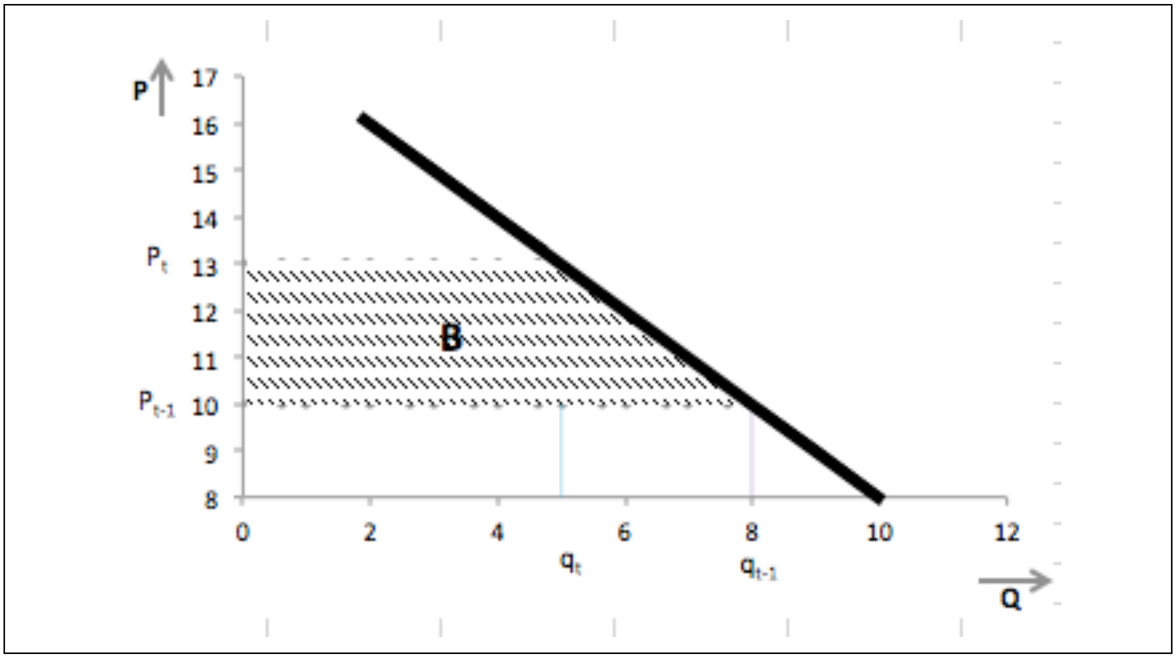

Figure 7-2 is a demand schedule with price on the y-axis and quantity demanded on the x-axis.

With demand described by homothetic preferences, the difference in total consumer surplus can be represented by the area of the polygon $P_tq_tq_{t\text{-}1}P_{t\text{-}1}$, which is labeled “B” and shaded with hash marks. Figure 7-2 also demonstrates why this is in fact a Consumer Surplus variation (instead of a variation in purchasing power or a compensating variation, for example): it gives us the amount by which total consumer surplus changes when the optimal bundle of goods changes. The area “B” is also described by the following equation:

(7-3) $$CS = P_tq_t * r * (1 - 0.5 * r/(1 + r)).$$

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[10] The expenditure share of the taxed good (evaluated at net-of-tax prices) remains constant in both the no-tax counterfactual and the current, with-tax state. This is a consequence of both homothetic preferences and of treating taxes paid (by individuals or households) as income losses.

The *CS* quantity described by equation 7-3 is equivalent to the burden (benefit) created by the indirect tax (subsidy); it is subtracted from disposable income to arrive at consumable income.

Notice that when we are evaluating the welfare losses (gains) created by the current tax (subsidy) schedules relative to a no-tax (no-subsidy) counterfactual, the Paasche welfare variation (generated by making use of an inelastic demand assumption) will never be greater than the Consumer Surplus welfare variation (generated by making use of a homothetic preferences assumption). The Consumer Surplus variation can only be taken over two optimal demand schedules; optimal demand will be higher (lower) in a no-tax (no-subsidy) state, and the difference between actual recorded demand (which we assume is equal to optimal demand in the current state) and optimal demand in the no-tax or no-subsidy counterfactual must be greater than zero. Araar and Verme[11] provide both a thorough computational treatment of the size of the differences in these two welfare variations by tax rate and detailed variable-level coding that generates these welfare variations in a cross-section of household-level expenditure.

Notice also that the discussion above has focused on the impacts of taxes or subsidies via a price channel, which means that the CEQ analyst should take care to exclude auto-production and auto-consumption, gifts, in-kind transfers, and other non-market-based purchase or receipt of goods and services when calculating the impacts of indirect taxes and subsidies. We have presented here only two simplifying assumptions, inelastic demand and homothetic preferences, that allow us to calculate incomes in the CEQ pre-fiscal counterfactual and in the post-fiscal environment reflected in the household survey. However, the CEQ analyst may decide that another demand system like Cobb-Douglas demand, the Almost Ideal Demand System, or the Exact Affine Stone Index better suits a particular country- or household-survey context and may therefore estimate welfare losses (gains) from indirect taxes (subsidies) under the assumptions specified by those alternatives. Araar and Verme provide a computational look at the difference in estimated welfare losses from price changes in different demand systems (including those mentioned above) and note that differences in welfare estimates across demand systems are “minimal as compared to changes in other parameters such as the price change or the budget share.”[12]

2 Indirect Impacts of Subsidies and Taxes

The direct impact on households of sales taxes or subsidies that change retail prices is relatively easy to trace through consumption expenditure records (if we are willing to make simplifying assumptions). However, the same price policies may also affect *intermediate* goods and services prices, and therefore producer prices, across the entire economy. If producers pass some of these higher or lower input prices on to other producers or to final consumers, households will bear more of a total burden or enjoy a

[11] Araar and Verme (2016).
[12] Araar and Verme (2016, p. 6).

larger total benefit than the direct impact alone would indicate.[13] In fact, a 32-country study using micro-datasets to trace the impact of fuels subsidies on household welfare showed that those subsidies produced equal or larger indirect than direct welfare impacts.[14] In other words, significant indirect effects are the international norm for developing countries.

CEQ assessments estimate incomes before and after the application of fiscal policies including indirect taxes and subsides; when a CEQ analyst can generate the total (direct plus indirect) impact of such policies on purchasing power, she will have a more comprehensive estimate of a fiscal policy's impact on poverty and inequality. When household expenditure levels are recorded with reference to retail prices *including* any subsidies or taxes, which is very common in household surveys, a household's real purchasing power may be overvalued when the price paid includes a portion that finances government consumption (such as with a sales tax) or undervalued when the price paid does not include the amount contributed by the government (such as with a subsidy). Such a misvaluation of purchasing power also occurs when households receive subsidy benefits or bear a sales tax burden indirectly.

3 Theory: The Price-Shifting Model

The following "price-shifting" model, which describes and quantifies the magnitude of sectoral changes in producer and retail prices resulting from any exogenous (demand, supply, or price) shock, provides a low-cost way for the CEQ analyst to estimate indirect impacts. In the section following this one, we demonstrate how to program such an exogenous shock and solve this model using available software packages.[15]

The model is low-cost because its solution is relatively easy to program using only information on the current structure of an economy at current levels of production, reflected in an input/output (I/O) matrix. It makes the following crucial assumption: exogenously-generated price changes are either "pushed forward" to output prices or "pushed backwards" onto factor payments.[16] Additional assumptions the model exploits are constant returns to scale in production, perfect competition, and reproducible fixed factors of production economy-wide. These assumptions allow the analyst to use the I/O matrix, which describes the input shares (of all sectors) in the output of all sectors at a

[13] See the appendix "Tax Incidence Analysis with Intermediate Goods" at the end of this chapter for a lengthier discussion of intermediate and final prices (including wages) in the presence of taxes.

[14] See Coady, Flamini, and Sears (2015).

[15] The indeterminate "shock" we describe here in the context of a CEQ exercise corresponds to the indirect tax or subsidy in question, for example, "We need to know what the welfare impacts of Country X's electricity subsidy are; let's go about that calculation by using the price-shifting model to determine what would happen if those subsidies were eliminated."

[16] An intermediate solution, where some of the shock to prices is absorbed by output prices and some by factor payments, is possible. However, because (1) CEQ assessments do not attempt to quantify the household welfare impacts from changes in factor prices, and (2) an input/output matrix does not observe factor payments, such intermediate solutions would manifest themselves here as a less-than-complete shock. See also footnote 12.

point in time and given prevailing prices, to generate producer price changes assuming production technologies and production input shares remain *fixed*.

Because it refers to a macroeconomic structure at a point in time and does not specify or generate any behavioral changes (by either households or firms) that result in changes to that macroeconomic structure, it is a static model. We therefore take results generated as an upper-bound estimate of the impact of any change in government-administered price policy on household welfare. The rest of this section follows Coady's appendix 3.2 closely; additional details can be found there.[17]

Suppose that for any economy at any level of production, there are three types of sectors: cost-push sectors in which higher input prices are pushed fully onto output prices; traded/non-cost-push sectors in which output prices are fixed (possibly because they are determined by world prices) and therefore higher *domestic* input prices are pushed backwards onto lower factor prices (or profits); and controlled sectors in which prices are controlled by the government.

For controlled sectors, producer prices are managed (at level $\tilde{p}$) so that retail prices ($\tilde{q}$) and producer prices are equivalent:

(7-4) $$\tilde{q} = \tilde{p},$$

and

(7-5) $$\Delta\tilde{q} = \Delta\tilde{p},$$

where either side of the equation may be specified exogenously (as part of a reform counterfactual, for example).

In the traded sectors (or those that are not cost-push), retail prices are determined by fixed (world) prices (p^w) and taxes (t^*),

(7-6) $$q^* = p^w + t^*,$$

and $q^* = p^* - t^*$ because taxes on domestic production alone must be pushed backwards onto lower producer prices and in turn lower factor payments or profits.[18] Changes in retail prices for traded/non-cost-push sectors are given by

(7-7) $$\Delta q^* = \Delta p^w + \Delta t^*,$$

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[17] See Coady (2008).

[18] If price shocks are absorbed by factor payments in the traded sectors, there may be an impact on labor incomes and returns to capital in that sector and (potentially all) other sectors. However, this model was not developed to solve for a general equilibrium.

where both terms on the right-hand side will be specified exogenously.

Finally, in the cost-push sectors, retail and producer prices are related according to

(7-8) $$q^c = p^c + t^c,$$

where t^c are sales or excise taxes (which can be negative, for example, for a subsidy). Producer prices are determined by

(7-9) $$p^c = p^c(q,w),$$

where q are the retail prices for intermediate inputs and w are factor prices. As all cost increases are pushed forward onto retail prices (and factor payments are therefore fixed), then

(7-10) $$\Delta q^c = \Delta p^c + \Delta t^c.$$

Using equation 7-9 and an input/output (I/O) matrix, the change in producer prices is given by

(7-11) $$\Delta p^c = \Delta q^c.\alpha.A + \Delta q^*.\beta.A + \Delta\,\tilde{p}.\gamma.A.$$

Here, price changes are $n \times 1$ row vectors (n = the number of sectors in the I/O matrix); α, β, and γ are $n \times n$ diagonal matrixes representing the proportions of cost-push, traded, and controlled commodities/sectors (respectively) in sectoral outputs; and A is an $n \times n$ technology coefficients matrix.

Further substitution (of equations 7-7 and 7-10 into 7-11) and solving for Δp^c yields

(7-12) $$\Delta p^c = \Delta t^c.\alpha.A.K + \Delta \mathrm{p}^w.\beta.A.K + \Delta \mathrm{t}^*.\beta.A.K + \Delta\,\tilde{p}.\gamma.A.K,$$

a solution based on exogenously-determined changes in taxes on, or prices in, cost-push, traded, and controlled sectors, exogenously-determined changes in world prices, and the inverse matrix $K = (I-\alpha.A)^{-1}$ where I is an $n \times n$ identity matrix. The typical element of the inverse matrix K, k_{ij}, captures the combined direct and indirect use of cost-push sector i used to produce one unit of cost-push sector j.

The CEQ analyst is concerned with government policies, so most often $\Delta p^w = 0$. And unless there is good information for any I/O sector in particular, or for the entire production economy, the CEQ analyst will most often make the convenient assumption that $\beta = 0$; that is, all sectors are either cost-push or controlled.[19] When those assumptions are made, equation 7-12 becomes

(7-12)' $$\Delta p^c = \Delta t^c.\alpha.A.K + \Delta\,\tilde{p}.(1-\alpha).A.K\,,$$

and the change in cost-push retail prices is then given by

(7-13)' $$\Delta q^c = \Delta t^c + \Delta t^c.\alpha.A.K + \Delta\,\tilde{p}.(1-\alpha).A.K,$$

which clearly separates the direct effect of the shock (the first term) from the indirect effects arising from changes in producer prices in the cost-push and controlled sectors (the last two terms).

CEQ-generated analytics and results are often disaggregated by specific policy, so the CEQ analyst will most often use the solution in equation 7-12' for a policy counterfactual that includes *at most* one unique change to price policy. That in turn means running one of the software options described below for the case where, for example, $\Delta t^c \neq 0$ while $\Delta\tilde{p} = 0$ (or vice versa). Theoretically this presents no difficulty because equation 7-12 indicates that changes to producer prices (and therefore to retail prices) are decomposable. Note also that even when $\Delta t^c = 0$, there may still be cost-push price changes arising from a shock to controlled sectors; these price changes arrive via indirect effects exclusively, which will be important to keep in mind during the value-added tax (VAT) discussion below.

This model's solution provides I/O-sector by I/O-sector changes in producer prices (after a shock). Therefore, the level of detail in the solution corresponds to the level of detail in the I/O matrix used. I/O matrixes do not typically distinguish between, for example, high- and low-quality types of a good, or between informally-produced groceries and formally-produced groceries. Fortunately, the level of detail in the I/O matrix carries over only partially to determination of welfare losses at the household level. As we shall see in the next section, calculating the indirect welfare losses (gains) from indirect taxes or subsidies requires knowledge of the amount by which prices are higher or lower in all sectors as a result of the tax (subsidy), as well as of the household budget shares for goods or services from all sectors.

4 Methods for Generating Indirect Effects of Indirect Taxes

In the price-shifting model described in the previous section, indirect taxes and indirect subsidies work similarly but with opposite signs: a tax will drive up the final price of a good (over its economic cost) while a subsidy should drive it down (below its economic cost). For example, for any individual good in the price-shifting model discussed in the

[19] Nonetheless, all the software packages below allow for traded sectors, or sectors where any shock to prices is (implicitly) pushed back onto factor payments instead of forward onto output prices.

previous section, the impact of a 10 percent subsidy will be equal in magnitude (but opposite in sign) to the impact of a 10 percent sales tax.

However, in practice subsidy impacts on household welfare are often relatively easier to account for. First, it is usually the case that a few easily recognizable and popular *items* (commodities like grains or other dietary staples, fuels, power) are subsidized; therefor purchases of subsidized goods can often be exclusively and exhaustively identified in the household survey alone and can be exclusively and exhaustively mapped to one aggregated economic sector. In contrast, taxes (VAT, excise, sales, import, and so on) typically cover entire *classes* of goods or services while exemptions are specific and narrow. Using the household survey alone, purchases of non-exempt taxed goods may be more difficult to exclusively and exhaustively identify. It may also be more difficult to exclusively map classes of goods to one economic sector. For example, if food is subject to VAT while there is an exemption for "basic commodities," the household survey may not ask households to recall specifically their expenditures on any one of the "basic commodity" items. Moreover, "basic commodities" might map correctly to both of the "agriculture products" and "grain mill products" sectors in the I/O matrix.

Additionally, economic theory offers few reasons to expect subsidy avoidance; in other words, if the same good is available at both subsidized and non-subsidized prices, it is reasonable to expect that all household purchases will be made at the subsidized price.[20] In theory and in practice, tax avoidance is to be expected. However, because tax avoidance is "hidden" (except in aggregate) from most of the records that CEQ relies on, it is often difficult for the analyst to acquire enough information to parameterize tax avoidance behavior and the impact of that behavior on household welfare. See the following section, "Taxes versus Subsidies," for additional discussion of these issues and for suggested solutions that can be programmed into the software tools described below. See the appendix "Tax Incidence Analysis with Intermediate Goods" at the end of this chapter for additional discussion on the theoretical impact of tax avoidance on final prices.

4.1 Practical Solutions for Indirect Effects

The CEQ analyst does not need additional software to evaluate the direct effects of indirect taxes; the consumption expenditure records (available in the household survey) together with the formulas for the Paasche and Consumer Surplus variations are enough to generate the item-by-item tax burden within the consumption expenditure survey or within the algorithm that creates CEQ income concepts. For the direct effects of indirect taxes or subsidies, the analyst will likely spend more time poring over the consumption expenditure item list and comparing it with the relevant indirect tax schedules to

[20] What's more, there is typically only one subsidy per item. While there are several different channels through which subsidies might affect the final retail price (government-managed prices, rebates, input subsidies, and so on), multiple modes of subsidy on the same good are not common. The same good or service may attract more than one tax type, however, each with its own associated tax-avoidance behaviors.

determine which of the goods or services attract an indirect tax and what the effective rate of taxation[21] and net-of-tax prices (for that item) are likely to be.

The rest of this section instead reviews software options for calculating indirect effects within the constraints imposed by the price-shifting model and its solution (as described previously), which takes place outside of the household survey. We will describe three publicly available software alternatives for estimating indirect effects and discuss general and specific steps the analyst must complete in order to use this software. These steps are as follows:

1. Prepare the input/output (I/O) matrix or Social Accounting Matrix (SAM).

2. Map household consumption expenditures to I/O production sectors.

3. Calculate the subsidy (tax) as a percentage of the market or reference price and map the subsidy (tax) schedule to I/O sectors.

4. Determine which (if any) I/O sectors would continue to have regulated or non-market prices if the price policy under consideration were revised.

5. Read in the I/O matrix or the SAM.

6. Enter exogenous price shocks and designate sectors with fixed prices.

7. Solve the model.

We will also provide examples as we go through each of the steps as well as one extended "toy" example at the conclusion of this section.

4.2 Software Options

The International Monetary Fund (IMF) has developed a set of Stata .do files that estimate the direct and indirect effects of indirect taxes (subsidies) using the price-shifting model described above.[22] SimSIP SAM[23] is a Microsoft Excel® based application with MATLAB® running in the background that can be used to analyze input/output tables and social accounting matrixes. SimSIP SAM can be used to analyze both quantity and price models[24] and is powerful enough to allow for structural path and structural change analysis. Finally, the SUBSIM[25] Stata package, a World Bank project

[21] An effective tax rate is calculated as total revenue collection for each tax divided by the tax base. As described in the section "Taxes versus Subsidies," in the context of evasion, it is often better to use these rates instead of statutory rates.
[22] The IMF .do files and instructions are found at http://www.imf.org/external/np/fad/subsidies/index.htm
[23] The SimSIP SAM tool is found at http://simsip.org/IOs___SAMs.html and the manual is at http://simsip.org/uploads/SimSIP_SAM.pdf.
[24] See Parra and Wodon (2011).
[25] SUBSIM software can be found here: http://www.subsim.org/

designed by Paolo Verme and Abdelkrim Araar, provides a set of tools with graphic interfaces and drop-down menus for rapid distributional analyses of subsidies and simulations of subsidy reforms.

In order to solve the price-shifting model using one of these software alternatives and to use results to trace the impact of price policy on household welfare, the following steps should be completed.

1. ***Prepare the input/output (I/O) matrix or Social Accounting Matrix (SAM).***
   Either an I/O matrix or a SAM can be used, but the analyst should choose an I/O or SAM year closest to the year of the primary household survey.[26] An I/O matrix can be created from a SAM. An I/O matrix or SAM can be used in all the software options discussed here, though preparation costs will be highest in the SAM-IMF or SAM-SUBSIM combinations. Both the OECD and the World Input-Output Database maintain I/O databases that are regularly updated.[27]

   I/O matrixes, including an I/O matrix recovered from an underlying SAM, are usually stated in flows: each row will describe the value of that sector's output by destination (that is, did the sector's output go to other sectors for use as production inputs or to households for consumption?) and each column will contain a complete list of the value of production inputs (from each sector). To calculate the weight of each input in each output, one must calculate the technical coefficients. This is done from the flows in the I/O matrix by dividing each cell in column j by the row sum (that is, total output) from the final row (where $i = j$). Technical coefficients express the value of inputs (in a sector) as a share of the value of total output from that same sector. The IMF software requires that the analyst create these "technical coefficients" from the I/O matrix while SimSIP SAM and SUBSIM will automatically create this matrix.[28]

2. ***Map household consumption expenditures to I/O table (or SAM) sectors.***
   There will likely be a far more disaggregated category list in the household consumption expenditures questionnaire than in the I/O sector list. The analyst will need to use his or her judgment in mapping each household questionnaire item to the relevant I/O sector. In cases where an item consumed by the household could plausibly come from more than one sector, it is reasonable to split each household's total consumption of that item among all plausible sectors according to sectoral share in total output (according to the I/O table). For example, if expenditures on "grains/cereals/milled wheat/milled rice" from the household survey could plausibly be mapped to either "Agricultural Products" or "Products from Millers" and those two sectors have total output values of 6 million and 4 million (respectively)

[26] If the I/O matrix is relatively old, making use of it would implicitly assume that the structure of the economy has not changed from the time it was assembled.
[27] The OECD database is available at http://www.oecd.org/trade/input-outputtables.htm and the World Input-Output Database is available at www.wiod.org.
[28] The analyst should take care, however, to provide to SUBSIM or SimSIP the precise form of the I/O matrix necessary because they are slightly different.

according to the I/O table, the analyst could direct 0.6 of a household's total item expenditures to "Agricultural Products" and the remaining 0.4 of the household's total item expenditures to "Products from Millers."

3. ***Calculate the subsidy (tax) as a percentage of the market or reference price and map the subsidy (tax) schedule to I/O table (or SAM) sectors.***
   The analyst should not expect the tax-schedule-to-I/O map to be seamless. The determination of the tax rate to apply may be particularly complicated due to likely evasion or weak enforcement (see the section "Taxes versus Subsidies" below for a longer discussion of which tax rates to apply). The analyst will need to use his or her judgment for both, although the determination of the correct tax rate to apply should also be discussed among the broader CEQ team.

4. ***Determine which (if any) I/O sectors would continue to have regulated or non-market prices if the price policy under consideration were revised.***
   For example, in the case of fuel subsidies, the relevant counterfactual may more likely be one where the government still controls the price of fuel even after eliminating the current subsidy. In such a counterfactual, fuel would be sold at a higher price, but the price at which it was sold would not necessarily be freely determined by market supply and demand.

5. ***Read in the I/O matrix or the SAM.***
   For the IMF software, simply change the following Stata code in order to read the correct "Leontief" or "Technology" coefficients I/O matrix into Stata:
   insheet using iotable.txt

   For SUBSIM, the analyst indicates to the SUBSIM interface where it should find the I/O matrix; the I/O matrix must be saved as a regular Stata .dta (dataset) file.

   For SimSIP SAM, one should copy and paste the regular, flow-based SAM (or I/O matrix) and then designate the SAM accounts that are endogenous and those that are exogenous to the price model under consideration.[29] For CEQ analytics, all SAM accounts other than the "activities" and "commodities" accounts should be made exogenous. If one is using SimSIP SAM with an I/O matrix and if the I/O matrix includes double-entry accounts for more than just the commodities sectors, those accounts should be made exogenous. The tool automatically computes the "Leontief" or "Technology" coefficients matrix and the inverse matrix (among others) once the "Inverse Matrix for Price Model" button is clicked.

6. ***Enter exogenous price shocks and designate sectors with fixed prices.***
   With the map generated in step 3, enter price change statements (in percent terms) for each sector that describes the counterfactual the analyst wishes to program and solve. For example, "If subsidies were removed, producer prices in this subsidized sector would increase by 20 percent."

[29] See section 4.1 in the SimSIP SAM manual.

In the IMF code, these statements appear as the following steps:

```
** Define price changes
local dpother=0.20         ; ** price change in petrol + diesel
local dpelec=`dpother'*(1/3); ** assume elec price increase is 1/3
                              ** of diesel & petrol price increase

** Assign simulated price increases to relevant sectors
matrix dp_sim[1,30]= `dpother'
matrix dp_sim[1,36]= `dpelec'
```

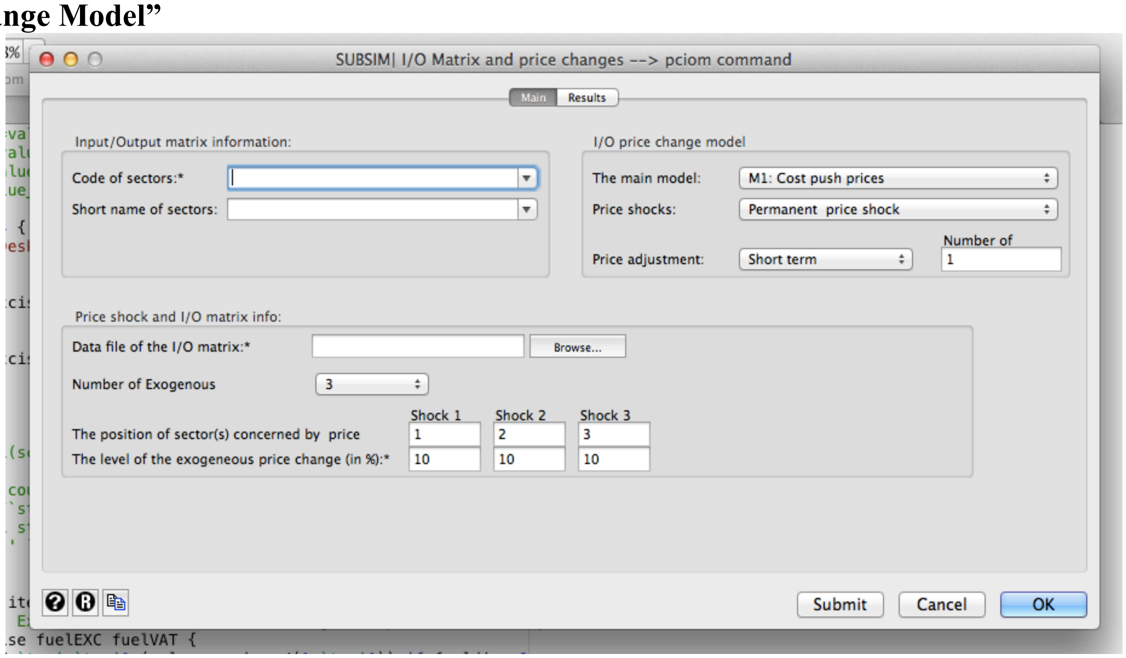
Now use the information from step 4 to designate sectors which would continue to have fixed (or regulated or controlled or administered) prices in the counterfactual. In the IMF code, this happens with the following statement (which occurs just above the previous piece of code):

```
local fixprice "30 36" ; ** these are the sectors whose prices are fixed
```

All the user needs to do is change the numbers to reflect the I/O sectors which will continue to have controlled prices in the counterfactual.

In the SUBSIM "I/O Matrix and price changes" package, the exogenous price changes should be entered in the "Price Shock and I/O Matrix info" submenu, as shown in figure 7-3:

Figure 7-3: Screenshot of SUBSIM "Price Shocks" Submenu in the "I/O Price Change Model"



Source: Screenshot from the SUBSIM program.

In SUBSIM one chooses whether the exogenous shocks are to sectors which will have fixed prices (after the shock). To do so, use the “Permanent price shock” choice in the “Price shocks” submenu in the “I/O price change model” options menu (see figure 7-3). When “Permanent price shock” is chosen, any sectors with price shocks (in the bottom left corner of the “Main” menu in the “I/O Matrix and price changes” package) will automatically become “fixed price” sectors, which means that those sectors will have regulated prices in the post-shock environment.

In SimSIP SAM, programming price shocks is equivalent to “designing an experiment for the price model.” To begin, open up a field for entering the sectors for which prices will be *fixed* in the counterfactual by selecting the “Specify supply constraints for Price model” button.[30] The analyst should enter a maximum price change of 1.0 for the relevant controlled sectors.[31] After specifying which sectors will have fixed prices, the analyst should execute the “Compute Mixed Multipliers for binding constraints” command in the pop-up window. Finally, select the “Experiment for Price Model Under Supply constraints” button.[32] A field or worksheet will open up in which the analyst should enter the price shocks that she wishes to program as the counterfactual to the relevant sectors.[33]

In order to generate the correct *indirect* effects, the price shocks (under the counterfactual) must summarize the change in *producer prices*. For example, there may be different unit subsidy amounts for household and industrial or commercial electricity users when electricity is subsidized. The analyst should use the household subsidy amount for the direct effects of the electricity subsidy and the industrial or commercial subsidy amount for the indirect effects.

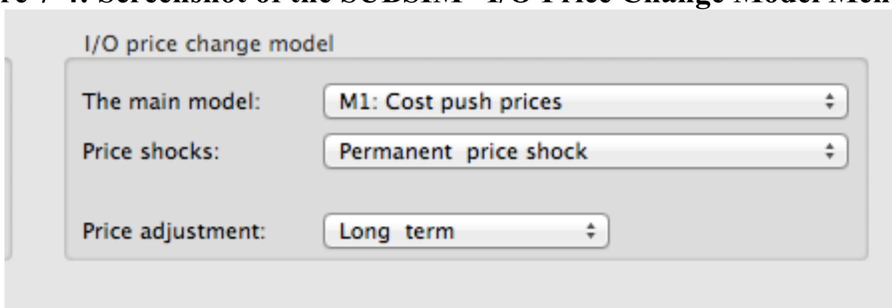
7. ***Solve the model.***
   The user can now run the counterfactual scenario with the IMF code and receive (as Stata output) a list of total price changes (in percent) by I/O sector. In order to let the program run, the user has to comment out the rest of the code beginning at Section 4:

```
*****************************************************************
*****
** 4. Read in the household expenditure data and map each expenditure
** item to one sector of the IO table. The idea is to arrive at a new
** mapped dataset having household expenditures by IO sector.
*****************************************************************
*****
```

[30] See section 4.7.4 which refers the reader to section 4.6.1 in the SimSIP SAM manual.
[31] This is the SimSIP SAM analog to the “local fixprice” statements in the IMF code. Within SimSIP SAM, designating fix-price sectors with a 1.0 entered in the “maximum price change” column in the “Specify supply constraints…” will limit the total price change in that sector to the price change entered in the “Experiment for Price Model…” sheet.
[32] See sections 4.7.5, 4.4, and 4.6.2 in the SimSIP SAM manual.
[33] This is the SimSIP SAM analog to the “matrix dp_sim” statements in the IMF code.

The SUBSIM "I/O Matrix and price changes" package allows for the solution of more than one type of model. The SUBSIM modeling choices that generate a model (and its solution) equivalent to the price-shifting model discussed above as well as to the model (and solution) that the IMF code and SimSIP are solving are the "M1: Cost push prices" and "Permanent price shock" and "Long term"[34] choices in the "I/O price change model menu" as shown in figure 7-4:

Figure 7-4: Screenshot of the SUBSIM "I/O Price Change Model Menu"



Source: Screenshot from the SUBSIM program.

SimSIP SAM also begins working after the "Experiment for Price Model under Supply Constraints" has been specified by the analyst. The resulting sectoral price changes will automatically populate their respective cells in the same field or worksheet that the analyst opened when selecting the "Experiment for Price Model under Supply Constraints" button.

5 Example Calculations: Steps 1 and 6-7

Suppose the CEQ analyst received the following I/O matrix describing the productive sector in some country-level economy producing food and fuel, in any year:

Table 7-1: Step 1

Sector/commodity	1	2	3	Household consumption
1=Food	40	5	7	34
2=Fuel	15	35	7	243
3=Widgets	2	22	10	120
Output	120	75	80	560

This I/O matrix describes the value of the inputs used in production in all sectors (the columns) and the uses or destinations of all sectoral outputs (the rows) in a double-accounting framework. Step 1 above indicates that we need a technology coefficients matrix, which looks like the following:

---

[34] The "Short term" option in SUBSIM corresponds to allowing the exogenous shock to have a first-round effect on prices in all other (non-shocked) sectors and then halting the recursive solution; the increased prices in non-shocked sectors do not then become higher input prices for all sectors.

Table 7-2: Step 1A

Sector/commodity	1	2	3
1=Food	0.3333	0.0667	0.0875
2=Fuel	0.1250	0.4670	0.0875
3=Widgets	0.0167	0.2930	0.1250

The technology coefficients in any sector's column do not sum to 1; we are taking the value of intermediate inputs over the total value of output, but the total value of output also includes payments made to factors (labor, land, capital) in addition to payments made for intermediate inputs.

Suppose the CEQ analyst knows that fuel prices are regulated; in particular, suppose that the analyst finds out that fuel prices are kept 10 percent below the market or reference price through government operations. In other words, the government uses fiscal expenditures to provide fuel at prices that are 10 percent below the price that would occur if government were not making those expenditures. Suppose also that the government would keep the price of fuels at the reference price even if there were no direct subsidy. The CEQ analyst is interested in the effect of the current subsidy on prices in the food and widget sectors under the cost-push model described above, and so for steps 3, 4, and 6 above, the analyst would enter a 10 percent price change for fuel as well as designate fuel as a "fixed price" sector.

Step 7 asks the analyst to solve the cost-push model of sector prices given the 10 percent shock introduced (representing the no-subsidy counterfactual) in fixed-price fuels. All the software options discussed above first calculate the matrix $K = (I - \alpha.A)^{-1}$. As stated above (see equations 7-12 and 7-13), the typical element of K captures the combined direct and indirect expenditure on cost-push sector i used to produce one expenditure unit's worth of cost-push sector j and the scalar α demarcates cost-push sectors (sectors 1 (food) and 3 (widgets) in our model) from the controlled sectors (sector 2 (fuel) in our example). For our example, $K =$

Table 7-3: Step 7

	s1	s2	s3
s1	1.5040	0.1444	0.1504
s2	0.0000	1.0000	0.0000
s3	0.0286	0.3380	1.1460

We can then create the indirect price changes for each sector (arising as a result of the exogenous shock or shocks) by multiplying the exogenous shock by α post-multiplied by K (following equation 7-13). Because the fuel (sector 2) is controlled, only food (sector 1) and widgets (sector 3) will have indirect price changes. We end up with $\Delta t^c.\alpha.A.K + \Delta \tilde{p}.(1 - \alpha).A.K =$

Table 7-4: Step 7A

	s1	s2	s3
Indirect price changes	0.0191	0.0000	0.0119

In other words, prices would be expected to increase in sector 1 (food) by approximately 1.9 percent and in sector 3 (widgets) by approximately 1.2 percent if the 10 percent fuel subsidy were to be removed. Notice that food's use of fuel (as represented by the technology coefficient in cell [2,1] in the I/O matrix) is greater than the widget sector's use of fuel (as represented by the technology coefficient in cell [2,3] in the I/O matrix), so it makes sense that the indirect effect is greater for food than for widgets.

We know that fuel was a "fixed price" sector and that the only exogenous shock was in fuel, so we can also list the total (direct plus indirect) price changes for all three sectors. That is,

$$\Delta t^c + \Delta t^c.\alpha.A.K + \Delta\,\tilde{p}.(1\text{-}\alpha).A. =$$

Table 7-5: Step 7B

	s1 = food	s2 = fuel	s3 = widgets
Total price changes	0.0191	0.1000	0.0119

This is the vector of sector-by-sector price changes that step 8 (below) calls on. Once the household consumption expenditure survey module is re-categorized according to I/O sectors (see step 2 above), all consumption expenditure in that I/O sector can be revalued according to new prices in that sector by either the "inelastic demand" or "homothetic preferences" scenarios listed above in the discussion of the direct effects of indirect taxes and subsidies.

8. ***Apply the sectoral price changes to the microdata.***
   a) Use the map generated in step 2 to determine which consumption items will experience which (I/O sector-wide) indirect prices changes.
   b) As for the calculation of the *direct* effects of indirect taxes and subsidies described above, use the formulas for the Paasche variation or the Consumer Surplus variation to calculate--for each item in a household's consumption basket--the change in purchasing power (or consumer surplus) that the household experiences through purchases of items that have experienced indirect price changes.

Steps 8a and 8b make it clear that a single tax (subsidy) can have both direct and indirect impacts. A fuel subsidy, for example, lowers the price of fuel that a household purchases for vehicles and cooking, but it also lowers the price of agricultural goods and public transport. Under the price-shifting model, households receive the full magnitude of the direct and indirect benefits (burdens) created by a subsidy (tax).

The calculation of indirect effects can also be completed within all the software programs discussed above if the user provides (as inputs) the household expenditure records. SimSIP SAM users can open up the "Poverty and Income Distribution Analysis" module; in the IMF code, section 4 through to the end of the program replicates step 8. SUBSIM users can provide a consumption dataset in which the items have already been mapped to the I/O sectors; SUBSIM will then apply the sector-level price change statements directly to this re-organized dataset. However, none of the software options calculates both the Paasche and Consumer Surplus variations in parallel. Therefore, we suggest that the CEQ analyst use the software only to generate the sector-level price changes (that would occur if a tax or subsidy were removed) and then "import" those price-change vectors into the household consumption expenditure survey to use in calculating the indirect PV and CS magnitudes for the taxes (or subsidies) being analyzed.

Whether the analyst migrates the sectoral price changes "by hand" to the microdata or feeds the microdata in to the software to allow the software to complete step 8, she should pause at the completion of step 7 to examine the price changes (listed by sector) for consistency and logic. If, for example, an increase in the price of fuel (due to the removal of a fuel subsidy) has very little impact on the transportation sector, then the analyst should re-examine the price change statements and, if necessary, the I/O table to determine the source of the inconsistency.

6 Taxes versus Subsidies

Subsidies should lower prices paid whether they are applied at the point of purchase by the consumer or given to goods and services producers themselves. Indirect taxes, meanwhile, have the opposite effect. For a good that is subsidized, the retail price is lower than the economic cost while household expenditure on the good (valued at market prices) will reflect only a portion of the economic cost or the price the good would fetch if there were no subsidy. For a good that is taxed, the retail price is higher than the economic cost, and expenditure by a household on that good represents some household consumption and some revenues collected by the government.

However, because businesses and households have reason to avoid taxes and because exemptions or exceptions for subcategories within a taxed class of goods may mean there will be reduced impact on *producer prices*, the CEQ analyst should take care to use empirical facts and judicious discretion in programming and simulating pre-fiscal counterfactuals for either taxes or subsidies. The CEQ analyst should use all the analytical tools at her disposal to faithfully reflect the *de facto*, rather than the *de jure*, situation. For example, when the statutory VAT rate is 18 percent, but the analyst notes that confirmed revenues from VAT divided by the confirmed sales value of the VAT-able base indicate that the *effective* VAT rate is something less than 18 percent, the analyst should apply the *effective* VAT rate to the household survey. Applying the statutory VAT rate to household purchases would likely overestimate the actual VAT burden on households.

The IMF code, SimSIP SAM, and SUBSIM can indirectly accommodate these complications within the price model described above. Take tax avoidance first: when there is no secondary source-data available on tax evasion, the analyst can use effective tax rates instead of policy rates. Effective rates are simply the ratio of (confirmed, verified, or audited) tax revenues divided by the taxable base according to national accounts. Depending on how disaggregated the information used to generate effective rates is, the analyst can then choose to apply one effective rate for all goods or services that attract the tax, or she can differentially apply the various sectoral effective rates, or she can choose to reduce the sectoral policy rates by the same factor by which the global effective rate is lower than the global policy rate. Where the IMF code, SimSIP SAM, or SUBSIM asks for price shocks, the analyst can use these effective rates instead of policy rates.

Whether an indirect tax "compounds" depends on the mechanics of the tax. In principle, a value-added tax should not compound as producers claim rebates on all VAT paid on inputs. However, an excise tax should compound as prices paid for inputs at any production stage will contain taxes paid during the previous production stage (for cost-push sectors under the assumptions of the price model described above). The extent of the compounding may also have to do with the structure of the market for the good or service being taxed – see the appendix "Tax Incidence Analysis with Intermediate Goods" at the end of this chapter for a detailed discussion.

The analyst can allow for a compounding tax by *not entering* any fixed price statements; that is, she can let prices in all taxed sectors change by the total (weighted) amount by which all input prices have changed as a result of the initial price shock (for example, the removal of the tax). This will result in the magnitude of the final, total, retail price change in some (possibly all) cost-push sectors being larger than the initial shock.

For a non-compounding tax, the analyst can enter fixed price statements for all sectors in which the counterfactual results in no change to *producer prices*. For example, suppose the counterfactual under consideration is the removal of a VAT system which has no exemptions. Retail prices in the sectors subject to VAT will drop by exactly the VAT rate, but no further: under a VAT system, producers receive rebates on all taxes paid on inputs so if a VAT is removed, producer prices will not change.

Exemptions within a VAT schedule make it more difficult to put bounds on the minimum and maximum of the actual total change in producer prices. If a VAT schedule designates certain "basic necessity" food items as exempt, for example, then the rebate chain is broken for those items: while consumers will not pay VAT upon purchase, producers of "basic necessity" food items do not receive rebates for any taxes on inputs. To the extent that such producers use standard-rated items as inputs, the final price of a "basic necessity" food item will reflect total input costs, which will now include any VAT paid (and not rebated) by the producer on inputs. Therefore, in a VAT system with at least one exempt good, it is no longer true that producer prices will not change if the VAT system is abolished; indirect effects will need to be calculated.[35]

As another example, domestic industrial or commercial users of imported goods are often not charged customs duties; in this case producer prices may not change if there is a shock to import duties. Then, as in the case of a VAT system with no exemptions, there will only be direct effects of import duties; there will be no indirect effect that operates through the change in producer prices.

In cases where the indirect tax system in application means that some producer prices would change and some would not in the price-shifting model under the counterfactual, the analyst should break up transmission of higher intermediate prices onto final prices into two steps. As a preliminary, identify the sectors for which *producer prices* will not change *directly*;[36] call the set of those sectors I and the set of all remaining sectors J. Then (1) enter price shocks (corresponding to the counterfactual) for I only and solve the price model. From the $1 \times (I + J)$ vector of total price changes, select the elements corresponding to J and (2) enter those as (the only) price shocks in a new price model. Once that new price model has been solved, the elements corresponding to I in the $1 \times (I + J)$ vector of total price changes will represent the indirect changes in producer prices that arise when, for example, non-exempt VAT sectors consume some VAT-exempt inputs in the production process. The *indirect* impact on producer prices in I plus the exogenous price shocks in I will be the total change in final prices in the I sectors.

The preceding discussion is meant to sound a gentle alarm: knowing the statutory rate of indirect taxation or the policy subsidy rate is not enough information to generate reasonable estimates of the impacts of the indirect tax and subsidy schedule on household purchasing power or welfare. The CEQ analyst will also need to parameterize as completely as possible the *de facto* application of the tax and subsidy schedule, including any weak tax or subsidy administration and tax avoidance as well as how informal purchases from unregistered sellers are to be treated.

7 Summary and Conclusion

The impact of indirect taxes (and subsidies) on poverty and inequality can be significant. However, standard poverty headcounts and inequality measures--calculated over a distribution of consumption expenditures--do not typically attempt to apportion the value of household consumption expenditure on goods and services separately from the value of indirect taxes paid while making consumption expenditures.

Accounting for the *direct* impact of indirect taxes (or subsidies) on household welfare and expenditure levels provides an estimate for only one channel by which fiscal policy

[35] For further discussion of the difference between VAT regimes and standard sales or excise taxes (vis-à-vis household welfare impacts), see Newhouse and Coady (2006).

[36] In a VAT system, these are the sectors that are not VAT-exempt (so producers receive a rebate on any VAT paid). In an import duty system, these are the sectors in which producers do not have to pay customs duties.

might affect inequality and poverty. The *indirect* impact of indirect taxes (or subsidies), which is created via the interaction of the production side of the economy with the fiscal system and with consumers, can be larger in magnitude than the direct impact as well as proportionally more important for lower-income consumers.

For example, in a twenty-country study covering Africa, South and Central America, Asia and the Pacific, and the Middle East and Central Asia, the indirect impact of higher fuel prices on welfare accounted for a nearly 60-percent share of the total impact (direct + indirect).[37] On average, the indirect impact was about 1.34 times greater than the direct impact for the poorest population quintile(s). In other words, the burden on the bottom 20 percent of the population created by the removal of fuel subsidies (or the imposition of a fuel tax) in these countries would be on average 134 percent higher if indirect impacts[38] were taken into account than if only direct impacts were taken into account. Including indirect effects, therefore, is likely to have a significant impact on the level of fiscal impoverishment (see Higgins and Lustig; reproduced as chapter 4 in this Handbook)[39] generated by fiscal policy.[40]

Low- and middle-income countries raise more in revenue from indirect than from direct taxes (on average), so a fiscal-incidence accounting will be missing an important piece if the burden of indirect taxes is not sensibly estimated. This chapter has provided a practical guide with theoretical underpinnings to the CEQ analyst for calculating the item-by-item and household-by-household burden or benefit of indirect taxes or subsidies. These procedures include steps for calculating both the direct and indirect burdens of indirect taxes so that the CEQ analyst can provide a reasonable description of the “pre-fiscal” counterfactual in which taxes or subsidies have been eliminated.

[37] See Coady, Flamini, and Sears (2015). Indirect impacts are calculated under the price-shifting model discussed in this chapter and are valued according to the Paasche variation (also discussed in this chapter). The results from two countries, Indonesia and South Africa, in Coady, Flamini, and Sears (2015) are based on CEQ assessments undertaken in collaboration with the World Bank; see Inchauste and Lustig (2017).
[38] Indirect effects created by the price-shifting model and valued by the Paasche variation.
[39] Higgins and Lustig (2016).
[40] The estimated impact of fiscal policy on inequality is also likely to change if the indirect effects of indirect taxes (or subsidies) are included because the magnitude of the indirect impact (measured as a share of the total impact) on welfare is greater for the poorest than for the richest quintile in all regions included in Coady, Flamini, and Sears (2015).

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Appendix A: Dealing with Taxes on Intermediate Stages of Production and Consumption

James Alm (Tulane University)

All taxes must ultimately be paid by someone, and one of the most basic questions asked by economists is "Who pays the taxes?" Any tax will cause individuals and firms to change their behaviors, and the resulting changes in product and factor prices will affect the "incidence" or the distributional effects, of the tax. This section discusses the notion of tax incidence, with a focus on the general issue of tax incidence and a specific and complicating issue in its applied analysis.

Economists have devoted much attention to the question of tax incidence.[41] Much of this work is theoretical. The focus here is on applied, microsimulation work as conducted in other parts of the Handbook. Several basic "principles" of tax incidence emerge from these analyses, which should be kept in mind in the discussion that follows.

A first principle is an obvious but often ignored one: *Only individuals can bear the burden of a tax*. Consider, for example, the company income tax. The company is the agent legally responsible for remitting the tax payment to the government, and so bears the "statutory incidence" of the tax. However, the company is merely a legal entity, and it makes little sense to claim that it is the company that bears the "economic incidence" of the tax. Instead, the economic incidence will be borne by one or more of several possible candidates, as produce and factor prices adjust in response to the company tax: the owners of the company, the consumers of the company's product (s), the workers of the company, the individuals who supply other inputs to the company, and even the owners of other companies. As another example, consider an excise tax on gasoline. The firm that collects the excise tax and remits it to the government will bear the statutory incidence of the tax, but again the economic incidence will depend upon the ways in which product and factor prices adjust to the excise tax. The final burden of the tax will likely be borne by consumes of gasoline via increased gasoline prices, or by those who supply inputs to the production of gasoline. As a final example, consider the employer's share of a payroll tax. The statutory burden of the tax is borne by the legal entity of the firm, but the economic incidence will ultimately be borne by its stockholders via a lower return, by its workers via lower wages, by its input suppliers via lower input prices, or by the consumers of its product via higher product prices. Tax incidence attempts to find ways to assign the burden of a tax to these individuals.

This reasoning suggests that a clear distinction must be made between who is legally responsible for paying a tax and who ultimately bears the true burden of the tax economic incidence. The process by which the statutory incidence of a tax is moved from those

[41] Much of this work builds on the analysis of Harberger (1962). For comprehensive surveys, see McLure (1975), Kotlikoff and Summers (1987), and Fullerton and Metcalf (2002). For examples of applied work for the United States, see Pechman (1986) and Fullerton and Rogers (1993); for surveys of applied work in developing countries, see Sahn and Younger (1999) and Bourguignon and da Silva (2003), among many others.

legally responsible to those who bear the economic burden is commonly referred to as "tax shifting". If a tax is shifted to consumers via higher product prices, then the tax is said to be "shifted forward"; if the tax is borne instead by workers or other input suppliers, then the tax is said to be "shifted backward".

A second principle of tax incidence is that *incidence of both the sources of income and the uses of income should be considered*. A tax may affect the prices of the products that individuals consume (or their "uses" of income). The same tax may also affect factor prices (or the "sources" of income). A full understanding of the incidence of the tax must incorporate both sides. Consider once again the excise tax on gasoline. To the extent that the price of gasoline increases, then individuals who purchase gasoline will pay some of the excise tax. To the extent that individuals who work for the gasoline companies receive lower wages (as, say, the companies reduce their demands for labor), then these individuals will also bear some of the burden of the excise tax. Both the sources and the uses of income must be analyzed in incidence analysis.

A third principle may be less obvious. *Incidence depends upon on the nature of the budgetary change; that is, incidence depends upon how the tax revenues are used*. A basic government accounting identity ensures that all government expenditures must be financed from one or more of several sources: tax revenues, borrowing (or the issuance of debt) from the public, or borrowing from the government via money expansion. Any change in tax revenues must be accompanied by a corresponding change in government expenditures, in government debt, in the money supply, or in another tax. The impact of any specific tax change on product and factor prices will clearly depend upon the precise change in these other instruments that accompanies the tax change.

The most common assumption here is that another tax (proportional to income) is changed in response to a specific tax change (or "differential tax incidence"), and this is the assumption that is made in the following incidence analysis. Other assumptions are possible.

A fourth principle is that *incidence depends upon market structure*. Tax incidence attempts to trace the impact of a tax on product and factor prices. Clearly, the ways in which prices are determined in these markets will affect the final burden of a tax. An excise tax imposed in a competitive market will have a different impact on prices than the same tax imposed in a market that is a monopoly or an oligopoly. Similarly, a tax imposed in a market in which all demands and supplies come from domestic sources will have a different impact on prices if it is imposed in a market in which international agents participate either on the demand side or on the supply side.

A related subprinciple is that *in a competitive market the incidence of a tax does not depend upon where it is imposed – on consumers of the produce or on producers of the product*. The tax simply drives a wedge between the gross-of-tax price paid by consumers and the net-of-tax price received by producers, and the origin of the wedge (for example, from the demand side of the market or from the supply side of the market) is irrelevant.

Finally, and most importantly, when a tax is imposed individuals will adjust their behavior to reduce their tax liabilities. Those who are better able to adjust their behavior – those who have a larger responsiveness, as measured by the "elasticity" – are better able to shift the tax burden to others and will bear less of the burden of the tax. This leads to a fifth principle: *Incidence depends upon elasticities*. For example, if consumers have a low response to gasoline prices, then consumers will bear more of the incidence of an excise tax on gasoline. Similarly, if workers are able to reduce their work effort or to shift their labor to untaxed sectors in response to an individual income tax or a payroll tax, then workers will bear less of the burden of an income or a payroll tax. [42]

How are these basic principles applied in practice? There are various types of incidence analysis. Here the focus is on microsimulation analyses, as conducted in other parts of the Handbook.

Suppose that we start with pre-tax/pre-transfer income of unit *h,* denoted I_h. Define the revenues that tax *i* collects as T_i and the amount of tax *i* that is borne by unit *h* (S_{ih}), so that S_{ih} incorporates the various incidence assumptions that must be made. For example, consider an excise tax on gasoline. If one assumes that an excise tax on gasoline is borne by consumers in proportion to their consumption of gasoline, then S_{ih} will measure the share of total consumption of gasoline for unit *h*. Similarly, the usual assumption about the incidence of the individual income tax is that it is borne in proportion to income, so that S_{ih} will equal the share of total income for unit *h*.[43] These S_{ih} terms are sometimes termed "allocators" because they allocate the tax burden of each tax instrument to the relevant units of taxation.

Given this framework, the post-tax/post-transfer income of unit *h*, or Y_h, is simply

$$Y_h = I_h - \sum_i T_i S_{ih} , \qquad (1)$$

where the total taxes paid by unit *h* equal $\sum_i T_i S_{ih}$. From this framework, different measures of taxes can be calculated, in order to characterize "Who pays the taxes?"

This basic framework is a simple one, indeed a deceptively simple one. For example, application of this framework requires answers to questions on the "unit" of taxation (for example, individual, household, deciles), on the appropriate "income" measure (for example, "comprehensive income", annual versus lifetime income, market versus non-market income, cash versus in-kind income), on the calculation of specific components of income (for example, capital income, rental income, evasion income), on the time frame

[42] For example, suppose that an average worker has annual wages of $30,000. If there is an individual income tax of, say, 10 percent and if workers bear the full burden of the tax, then the average worker's net-of-tax wage income falls by $3000 (=10 percent X $30,000) to $27,000. However, suppose that the presence of the 10 percent tax causes workers to reduce their supply of labor to the taxed sector, perhaps by working fewer hours in total or by working fewer hours in the taxed sector and more in the untaxed, informal sector. If the average wage rises to, say, $31,000, then labor has been able to shift $1000 of the $3000 tax to employers via a higher gross-of-tax wage; employers may in turn shift some of their burden to consumers via higher product prices or to other input suppliers via lower input prices.

[43] Instruments can also include transfers or subsidies, in which case T_i is simply a negative number (for example, the transfer/subsidy increases the post-tax/post-transfer income of unit *h*).

of analysis (for example, annual versus lifetime), on the specific taxes (and transfers) examined, and on assumptions about the allocators (for example, is there a consensus on incidence?). In most all cases, there are no simple answers, especially for developing countries where data are often limited, even problematic. Even so, answers to these – and many other questions – are discussed at length elsewhere in this Handbook.

Here one specific issue is examined. The basic framework implicitly assumes that each tax T_i is imposed either on *final* consumption of consumers or on *final* income of factor owners; that is, the framework assumes that all taxes are imposed at a final stage of consumption ("uses") or at a final stage of income ("sources"). However, in many cases a tax may be imposed at intermediate stages of consumption or production. This is especially a concern for the analysis of petroleum excise taxes and import duties, even the value-added tax (VAT). For example, import duties (both positive and negative) in developing countries are typically imposed on a wide variety of imported goods, including: food, automobiles, petroleum products, beverages, tobacco, clothing, raw materials, and capital goods. As these taxes work their way through the intermediate stages of production, they affect the prices both of the products that are produced (and that become inputs for the succeeding intermediate stages of production) and of the factors that are used to produce these intermediate inputs. Assigning these tax burdens only to final goods and services does not accurately capture the true burden of these taxes. Note that this broad issue is related to the narrower issue that arises in many developing countries: a household is both a consumer of goods and a producer of goods. In this setting, a household may consume some goods in the process of producing other goods, so that taxes at one stage of production or consumption may affect prices of products and factors at other stages of production or consumption.

As one example of this type of "cascading", estimates for the United States indicate that consumers bear on average only about 60 percent of states' general sales taxes, with individual state estimates ranging from 30 to 90 percent (Ring, 1989, 1999), even though it is usually assumed that consumers bear the entire burden of a general sales tax. Put differently, these estimates indicate that businesses pay about 40 percent of general sales tax revenues because many business purchases of (intermediate) goods and services are in fact taxed under the general sales tax, despite the presumed intent of a general sales tax to tax only final goods and services. Estimates for developing countries (Ahmad and Stern, 1990, 1991) show a similar, indeed a more extreme, pattern.

How are these types of taxes incorporated in microsimulation incidence analysis?[44]

One approach essentially ignores the taxation of intermediate products, and attempts to assign the burden of all taxes to final consumers and factor owners. This approach

[44] It should be noted that an alternative to microsimulation analyses is the use of computable general equilibrium (CGE) modeling. Here multiple sectors and so multiple stages of production are introduced, so that the CGE approach is able to examine the incidence of taxes on intermediate inputs on household units. CGE modeling has traditionally been more aggregate in its analysis. For example, the CGE model in Ballard and others (1985) has 19 production sectors, 15 consumption goods, and 12 consumer groups. However, more recent models have increased in size significantly in size, and are able to incorporate multiple production sectors, consumption goods, and consumer groups.

recognizes the bias that is introduced, but believes that the bias is small and is outweighed by the convenience of the approach. For example, Alleyne and others (2004) assume that the incidence of petroleum excise taxes and import duties on petroleum is borne by consumers in proportion to their consumption of cars, even though these taxes are paid in significant amounts by businesses. They also assume that import duties on capital goods are borne by consumers in proportion to their consumption of nonfood items, even though the overlap between capital goods and nonfood items is tenuous. Many other applied incidence studies have often made similarly problematic incidence assumptions.[45]

A second approach and more recent microsimulation approach attempts to address the taxation of intermediate goods directly, by tracing the impact of taxes on intermediate goods through the various stages of production. This approach leads to more accurate, and more disaggregated, estimates of incidence than either of the above methods, although at some added cost in complexity and implementation.

This approach proceeds by utilizing input-output tables of a country. As pioneered by Wassily Leontief, an input-output table records the flows of products from each sector considered as a producer to each sector considered as consumers.[46] Application of input-output analysis to tax incidence proceeds by tracking the impact of taxes on intermediate goods through the input-output table to final consumers. For example, some portion of, say, a petroleum excise tax will fall *directly* on households via their consumption of personal transportation and also *indirectly* on households via their consumption of other goods that require transportation as an input. The final incidence of the petroleum excise tax is calculated as the sum of the direct and indirect effects of the tax, so that the incidence calculations will incorporate both the direct price increase in petroleum and the indirect price increases of all other products that use petroleum in production.

To illustrate, suppose that a simple economy consists of n sectors. Each sector i produces x_i units of a good, and each sector j requires a_{ij} units of x_i to produce 1 unit of good x_j. Then the total demand for x_i can be written as:

$$x_i = a_{i1}\,x_1 + a_{i2}\,x_2 + a_{i3}\,x_3 + \ldots + a_{in}\,x_n + d_i = \textstyle\sum_j a_{ij}\,x_j + d_i\,, \qquad (2)$$

where d_i is the final demand for good i. The a_{ij} terms are called "input coefficients". When we consider the entire economy, all n sectors can be represented in matrix form as:

$$\boldsymbol{x} = \boldsymbol{Ax} + \boldsymbol{d}\,, \qquad (3)$$

so that

$$\boldsymbol{x} = (\boldsymbol{I}\text{-}\boldsymbol{A})^{-1}\,\boldsymbol{d}\,, \qquad (4)$$

where $\boldsymbol{x}$ and $\boldsymbol{d}$ are n X 1 vectors, $\boldsymbol{A}$ is an n X n matrix, $\boldsymbol{I}$ is an n X n identity matrix, and $(\boldsymbol{I}\text{-}\boldsymbol{A})^{-1}$ denotes the inverse of the $(\boldsymbol{I}\text{-}\boldsymbol{A})$ matrix.

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[45] For example, see Wasylenko (1987) and Alm and Wallace (2005), both for the Jamaican tax system.
[46] Leontief's major articles are reprinted in Leontief (1986).

For example, suppose that the economy consists of 3 sectors (x_1, x_2, x_3) with corresponding input coefficients a_{ij} and final demands d_i given by:

$$\boldsymbol{A} = \begin{vmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{vmatrix} = \begin{vmatrix} 0.2 & 0.3 & 0.2 \\ 0.4 & 0.1 & 0.2 \\ 0.1 & 0.3 & 0.2 \end{vmatrix}$$

$$\boldsymbol{d} = \begin{vmatrix} 10 \\ 5 \\ 6 \end{vmatrix}.$$

Reading across the rows of the $\boldsymbol{A}$ matrix, we see how the output of each sector is used in the sectors (for example, a_{12} shows that 0.3 units of x_1 are required to produce 1 unit of x_2). The vector $\boldsymbol{d}$ indicates the final demands for each sector (for example, the final demand for x_3 is 6 units). Using the equation (4) for the solution for $\boldsymbol{x}$ (= $(\boldsymbol{I}\text{-}\boldsymbol{A})^{-1}\ \boldsymbol{d}$), the equilibrium in this simple economy requires that:

$$\boldsymbol{x} = \begin{vmatrix} 24.84 \\ 20.68 \\ 18.36 \end{vmatrix}.$$

Note that this solution is represents a first-order linear approximation. Note also that this framework relies upon a variety of restrictive assumptions, such as constant returns to scale production and fixed and unchanging production requirements.

It is especially the $\boldsymbol{A}$ matrix of input coefficients that is used in the incidence analysis to attribute a tax on intermediate inputs to the final goods.

Applying this approach to tax incidence relies upon a simple price formation equation, which represents a slight variant on the solution for $\boldsymbol{x}$ in equation (4):

$$P_j = \textstyle\sum_i a^d_{ij} P_i + (1+\tau^d_j)VA_j + \sum_i (1 + \tau^m_i)(1 + t_i)\, a^m_{ij} + s_j P_j , \qquad (5)$$

where P_j is the price of good j, a^d_{ij} is the input coefficient of *domestic* input i for sector j, a^m_{ij} is the input coefficient of *imported* input i for sector j, τ^d_j is the *domestic* good value-added tax rate for sector j, τ^m_j is the *imported* good value-added tax rate for sector j, VA_j is value-added in sector j, t_i is the import tariff rate for sector i, and s_j is the excise or other tax rate on sector j. Note that P_j appears on both sides of the equation (5), just as $\boldsymbol{x}$ appeared on both sides of equation (4). Accordingly, the equation can be solved for the price P_j that satisfies the various relationships. In particular, the final price of sector j will depend upon the *direct* effects of sector-j specific taxes on sector j (via the value-added tax on good *j* and the excise/turnover tax on good *j*) as well as upon the *indirect* effects of all taxes on intermediate goods (via their effects as these taxes work through the complicated input-output relationships). Equation (5) can also be summed across all sectors to derive the solution for all prices in the economy, as functions of direct and indirect effects of all taxes.[47]

The incidence of any particular tax (say, on good *i*) on the price of good *j* is then calculated in a straightforward way. The price of good *j* is calculated with all taxes included, and then the price is calculated when setting tax *i* equal to zero. The incidence of tax *i* on good *j* is simply the difference in prices. The change in P_j can then be used in standard calculations to determine the incidence of the tax at the household level, based on household consumption of the relevant goods, where the incidence now reflects both direct and indirect effects of taxes.

Note that it is straightforward to introduce various constraints on the price equation (5) that reflect the specific economic environment of the country. For example, the prices of some goods in a small open economy (such as, tradeable goods) are likely to be fixed, determined by international markets and not by domestic markets. In this case, the relevant price is pre-determined, and the analysis proceeds by the substitution of the fixed price into the system of equations.

The input-output approach is more cumbersome to apply than the simpler microsimulation approach. In particular, its application requires a detailed input-output table of the relevant economy. The approach also depends upon the validity of the various assumptions underlying the construction of input-output tables, as discussed earlier. Even so, it allows a more accurate assignment of tax liabilities at the household level.

Overall, it should be evident that are many difficult issues in applied microsimulation incidence studies. As a result, there is no single "best practice" for these studies, and extensive robustness tests are required to test the sensitivity of results to specific assumptions.

[47] For detailed applications of this approach, see Bird and Miller (1989), Rajemison and Younger (2000), and Rajemison, Haggblade, and Younger (2003).

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