The Total Fiscal Cost of Indirect Taxation:
An Approximation Using Catalonia's Recent Input-output Table

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Abstract

In this note we quantify to what extent indirect taxation influences and distorts prices. To do so we use the networked accounting structure of the most recent input-output table of Catalonia, an autonomous region of Spain, to model price formation. The role of indirect taxation is considered both from a classical value perspective and a more neoclassical flavoured one. We show that they would yield equivalent results under some basic premises. The neoclassical perspective, however, offers a bit more flexibility to distinguish among different tax figures and hence provide a clearer disaggregate picture of how an indirect tax ends up affecting, and by how much, the cost structure.

Keywords: tax load, fiscal cost, indirect taxation decomposition

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I. Introduction

Indirect taxation pervasively affects all kind of economic transactions of goods, services and factors in modern economies. Tax collections of all types allow the government to run its consumption and investment spending plans as well as its social welfare policies. Indirect tax collections, in addition, also condition the environment in which agents make decisions. The non-neutral, distorting role of indirect taxes is well-known in the public finance literature. Less known is the fact that general equilibrium effects may exacerbate the initial distortion of an indirect tax. Beyond initial or first round effects on prices there are also second-round effects that track the network of cost interdependencies of an economy. This is particularly so in the case of production taxes or labour use taxes. In a general equilibrium framework the cost of a good or service depends upon the cost of all necessary inputs. Inputs in turn are nothing but goods, services and factors purchased by firms. Whenever these inputs are taxed, a fiscal cost needs to be added to the rest of productive costs. As long as there is a recursive chain of purchases, fiscal costs will accumulate beyond the first round effects. A detailed accounting of these cumulative costs is therefore required to distinguish first-round effects (or visible tax load) from second-round effects (or cloaked tax load) behind the total induced tax cost of a given commodity or service.

Any conceptual distinction between visible and cloaked tax loads first entails a *computation* of total tax load to then proceed to compute its *decomposition*. In order to carry out computations, though, two pieces of information are needed. First and foremost an empirical database that supplies the numerical background depicting the accounting structure of the economy. To this end a newly developed input-output table for the economy of Catalonia in 2001 is available. Secondly we need to put forward some working assumptions to extend the accounting relationships in the empirical database into behavioural relationships. In other words, we need a modelling facility able to capture and make operational the interdependency effects implied by indirect taxation. Clearly the database structure restricts the characteristics of the modelling facility. A Social Accounting Matrix, for instance, allows the development of a full-fledge Computable General Equilibrium model whereas an input-output table does not. Despite this limitation, however, an input-output table with a detailed disaggregation of indirect taxes does offer a novel way to study the role and impact of taxes on prices.

The structure of price models for linear economies is well known. Constant returns to scale and fixed coefficients under competitive profit maximization give rise to zero profit price rules. McElroy et al (1982) study general price formation for the US whereas Derrick and Scott (1993), for instance, examine the role of the sales tax in prices. Cardenete and Sancho (2002), in turn, develop a model of regional prices with taxes and Cardenete et al. (2007) exploit the structure of a regional interindustry model to assess the impact of a fuel tax. All these works depart from the baseline tax structure and study how marginal or limited changes in some of the tax rates affect prices. Here we propose to take advantage of the mathematical series expansion of the price structure to isolate and identify the total induced cost of indirect taxes and do so using both a Classical and a Neoclassical perspective. In the first case we extend the notion of value to account for "total tax value" in a manner coherent with labour value theory. In the second case we formulate a simple price model and show how total tax cost can be calculated. Under a simple scenario of a unique indirect tax we see that both approaches yield the same result. The Neoclassical approach, however, turns out to be a bit more flexible when more than one indirect tax is being levied.

In the next section we examine the methodology whereas in Section III we present some empirical results. The Concluding remarks section ends the note.

II. The Methodological Approach

Let us consider a simple economy described by a matrix of technical coefficients *A* and vectors of coefficients for primary factors ℓ (labour services), *k* (capital services) that combine in fixed coefficients with all material inputs in *A*. Suppose now that an indirect tax t_j is levied on each unit of good *j*. Each unit of *j* commands an immediate or fist-round tax load of t_j units and this amount is passed onto each subsequent production phase. To elicit the cumulative effect of the indirect tax rates, we declare T_j to be that total cumulative value. T_j includes both the fist-round (visible tax load) and the second-round (non-visible or cloaked tax load) effects behind each unit of good *j*. The non-visible tax load includes all indirect taxes incorporated into the material inputs needed to produce a unit of *j*. These input requirements are described by column *j* of matrix *A*. Therefore for *j*=1, 2, ... , *n*

$$T_j = t_j + T_1 \cdot a_{1j} + T_2 \cdot a_{2j} + \ldots + T_n \cdot a_{nj} \tag{1}$$

In matrix notation this becomes

$$\left(T_1, T_2, \ldots, T_n\right) = \left(t_1, t_2, \ldots, t_n\right) + \left(T_1, T_2, \ldots, T_n\right) \cdot \begin{bmatrix} a_{11} & a_{21} & \cdots & a_{n1} \\ a_{21} & a_{22} & \cdots & a_{n2} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{bmatrix} \tag{2}$$

or in more compact notation

$$T = t + T \cdot A \tag{3}$$

Under standard mathematical viability conditions[1] for the technology represented by A we may calculate T by

$$T = t \cdot (I - A)^{-1} \tag{4}$$

Because of the viability of A we can use the non-negative matrix series expansion

$$T = t \cdot (I + A + A^2 + A^3 + \ldots + A^k + \ldots) = t + t \cdot A + t \cdot A^2 + t \cdot A^3 + \ldots + t \cdot A^k + \ldots \tag{5}$$

This expression is telling us that total tax T load includes the visible tax load t and a recursive, cloaked tax load given by $t \cdot \sum_{k=1}^{\infty} A^k$. In general, the added tax load in phase k of the productive process is measured by $t \cdot A^k$ where A^k are the material inputs needed to produce the inputs A^{k-1} employed in the previous productive phase. As long as we know the tax rates t and the technology A we are able to calculate total tax cost T. Notice the formal similarity of this procedure with the procedure to calculate labour values[2].

Let us now turn to price determination. Under our technological and behavioural assumptions, standard micro-theory implies that the price of commodity j for this economy is given by

$$p_j = \left(w \cdot \ell_j + r \cdot k_j + \sum_{i=1}^{n} p_i \cdot a_{ij} \right) + t_j \tag{6}$$

where w and r stand for the wage rate and the unitary price for capital services. In matrix notation and solving for the reduced price form we have

$$p = w \cdot \ell + r \cdot k + p \cdot A + t = \left(w \cdot \ell + r \cdot k + t\right) \cdot \left(I - A\right)^{-1} \qquad (7)$$

provided the viability conditions for matrix A hold. By setting t=0 we can recompute prices p_0 without any tax impact. The difference between initial prices p and prices p_0 without indirect taxation t indicates the total impact of taxes on prices

$$\Delta p = p - p_0 = t \cdot \left(I - A\right)^{-1} = T \qquad (8)$$

which turns out to yield exactly the same total impact as the Classical value computation in (4).

In developing empirical applications, however, some care must be taken to guarantee that tax rates in the model are adequate or close representations of the way the tax code is implemented in practice. We know that some indirect tax rates are levied on specific inputs, whereas other tax rates adopt an *ad-valorem* format. For instance, taxes on labour use will, in the first-round, affect only labour inputs ℓ. An output tax, in turn, can be applied to intermediate inputs or to activities as a surcharge. Even more, if the database has been constructed using the SEC methodology of basic prices some indirect taxes will fall on intermediate inputs, regardless of their domestic or imported origin. And some indirect taxes, like VAT, will not appear reflected in the price equation since VAT is not, in principle, a cost for firms. Expression (6) should be correspondingly adapted to any of these peculiarities. Consider, as an example, a simple interindustry model with a single primary factor (labour). Then the price equation with an *ad-valorem* output tax tp_j on intermediate inputs, an *ad-valorem* tax ts_j on labour use and a unitary activity tax ta_j will take the form

$$p_j = \left((1+tp_j) \cdot \sum_{i=1}^{n} p_i \cdot a_{ij} \right) + ta_j + w \cdot (1+ts_j) \cdot \ell_j \tag{9}$$

In matrix terms and solving for the reduced equation we would find

$$p = \left(\underline{1} \cdot D_{ta} + w \cdot \ell \cdot D_{ts} \right) \cdot \left(I - A \cdot D_{tp} \right)^{-1} \tag{10}$$

where $\underline{1}$ is a vector of ones and D_t stand for the diagonalised matrices of tax rates. Using again the series expansion, we see that matrix $\left(I - A \cdot D_{tp} \right)^{-1}$ can now be written as

$$\left(I - A \cdot D_{tp} \right)^{-1} = I + A \cdot D_{tp} + (A \cdot D_{tp})^2 + ... + (A \cdot D_{tp})^k + ... \tag{11}$$

From (10) and (11) we observe how indirect tax rates affect total cost and accumulate over the production phases via two different effects. First, there is a *summation* effect (i.e. the powered output tax D_{tp}) and, second, there is a *compound multiplication* effect (i.e. the labour and activity taxes D_{ts} and D_{ta} affecting the series expansion) both of them contributing to total cost.

By setting each indirect tax vector equal to zero we may therefore unveil the tax load on prices implied by that tax accounting for first-round and second-round interdependence effects and the particular tax implementation.

III. Database and Results

The implementation of the Classical and Neoclassical approaches requires a database and its adaptation to the stated model's assumptions. Ideally a symmetric input-output table where goods and sectors are linked in a one-to-one mapping is needed. In real-world terms, simple production is unusual and joint production does take place. To develop a model, however, some compromise between data and assumptions has to be put forth. In the recently developed 2001 input-output table for Catalonia (IDESCAT, 2006), statisticians have opted for a so-called *extended* destination table with a synthesis of sectors and goods to match destination with origin. Under this construction assumption, the table presents a disaggregation with the same number of goods than sectors and has a symmetric, squared format. Given this structure we use an industry technology assumption to implement our models and we hypothesize the database to represent the baseline equilibrium. The database contemplates fourteen productive accounts four different indirect tax categories: an output tax, an activity tax, a labour tax and tariffs on traded goods. We calibrate all tax rates to being effective, equivalent tax rates so as to reproduce tax collections as reported in the baseline equilibrium.

Table 1 shows total tax load for an aggregate indirect tax and its decomposition into visible and cloaked tax load both in absolute and relative terms. A first observation is that the cloaked tax load tends to dominate over the visible one, except for sector 1 (Agriculture) which is traditionally a subsidy receiving sector. In average terms, for instance, the cloaked tax load is almost twice as large as the visible tax load with sector 3 (Manufactures) having the largest relative weight of cloaked over visible load (133 percent) and sector 11 (Public services) the least relative weight (25 percent). The analysis therefore reveals how and by how much those sectors more vertically integrated (like Manufactures, unlike Public services) end up yielding a larger tax load as a proportion of the initial tax rates. These results indicate that, on average, for each monetary unit levied on transactions the general equilibrium effects induced by technological interdependencies will contribute to the doubling of the indirect tax load.

Table 2 presents the sectoral effects on prices of eliminating each of the four indirect categories. Each figure reports the hypothetical price of providing goods should the corresponding tax rate be eliminated and where reference prices are calibrated to be unitary for easy comparison. The first column reports the hypothetical elimination of the tax on labour use. While average price reduction would be close to 6 percent, the lowest price effect is found in sector 2 (Extractive industry) and the larges in sector 11 (Public services). An explanation lies in the fact that these sectors have, respectively, the lowest and largest share of wages in total cost, as can be seen examining the input-output table. When we observe all tax categories, the labour tax is clearly the tax category with the highest impact on total cost. The remaining three indirect tax categories, when taken together, amount to about a 1 percent of implied total cost. These figures can also be seen in terms of competitive costs. For instance, we can read in the input-output table that in Catalonia the labour tax amounts to a 25.30 percent of total labour cost. On average terms and taking account of the weight of this tax category, a 1 percent of competitive cost is associated to 4.28 percent points in the labour tax. In other words, the average effective tax on labour should fall from 25.30 percent to 21.02 percent to gain a price reduction of 1 percent. Similarly, one could also see that a competitive gain of 1 percent is associated to a reduction of 0.49 percent points in the activity tax, 1.68 points in the output tax and 1.47 points in tariffs.

4. Concluding remarks

The interindustry model turns out to offer a valuable tool to assess and quantify the general equilibrium effects exerted by indirect taxation both at an aggregate and disaggregate level. Provided an empirical interindustry table is available, value and price models capable to discern total tax load due to indirect taxation are implementable. Under some working assumptions, this tax load can be separated into visible and cloaked tax loads. Also, total tax load can be distinguished and attributed to the different indirect tax categories. Of these, the labour tax turns out to be the one with the highest impact on total cost. These results could be useful for tax reform or price containment policies as they indicate which indirect tax entails the highest accumulated price distortion and where.

Table 1

Total tax load

Sectoral tax load	Visible tax load	Cloaked tax load	Visible load in percent	Cloaked load in percent	Percent increase over visible load
1. Agriculture	-0,0204	-0,0055	0,7881	0,2119	-73,12%
2. Extractives	0,0066	0,0124	0,3489	0,6511	86,64%
3. Manufactures	0,0229	0,0535	0,2999	0,7001	133,48%
4. Energy	0,0468	0,0787	0,3727	0,6273	68,29%
5. Construction	0,0564	0,1185	0,3223	0,6777	110,29%
6. Commerce	0,0545	0,0973	0,3588	0,6412	78,68%
7. Hotel services	0,0572	0,0970	0,3711	0,6289	69,49%
8. Transportation & Communications	0,0429	0,0906	0,3215	0,6785	111,08%
9. Financial mediation	0,1099	0,1581	0,4100	0,5900	43,91%
10. Services to firms	0,0580	0,0896	0,3930	0,6070	54,44%
11. Public services	0,1932	0,2417	0,4443	0,5557	25,09%
12. Educational services	0,1427	0,1994	0,4171	0,5829	39,73%
13. Health services	0,1191	0,1723	0,4088	0,5912	44,60%
14. Other services	0,0737	0,1215	0,3776	0,6224	64,80%
Weighted average	***0,0441***	***0,0809***	***0,3469***	***0,6531***	***97,96%***

Table 2

Tax load by tax category

Sectoral weigth by tax category	No tax on labour	No activity tax	No output tax	No tariffs
1. Agriculture	0,9835	1,0208	1,0061	0,9997
2. Extractives	0,9908	0,9999	0,9984	0,9999
3. Manufactures	0,9556	0,9998	1,0010	0,9988
4. Energy	0,9568	0,9891	0,9815	0,9998
5. Construction	0,9123	0,9918	0,9959	0,9995
6. Commerce	0,9290	0,9937	0,9952	0,9997
7. Hotel services	0,9305	0,9973	0,9912	0,9997
8. Transportation & Communications	0,9329	0,9980	0,9900	0,9997
9. Financial mediation	0,9073	0,9910	0,9569	1,0000
10. Services to firms	0,9474	0,9788	0,9941	0,9999
11. Public services	0,8404	0,9944	0,9468	0,9998
12. Educational services	0,8633	0,9997	0,9722	0,9999
13. Health services	0,8850	0,9973	0,9694	0,9996
14. Other services	0,9161	0,9934	0,9880	0,9998
Weighted average change in percent	***5,9019***	***0,4014***	***0,5630***	***0,0694***

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[1] See Nikaido (1972), chapter 3, or the seminal Hawkins and Simon paper (1949).
[2] See Morishima (1973), chapter 1.