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Tax incidence under imperfect competition: Comment

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ABSTRACT

Delipalla and O'Donnell (2001) contains a formula for the incidence of specific and ad valorem taxes in a conjectural variation oligopoly model with potentially asymmetric firms. The formula is incorrect. We derive the correct formula and provide a discussion of the error and its implications for empirical studies of pass-through.

1. Introduction

Delipalla and O'Donnell (2001), henceforth D–O, contains a formula for the incidence of specific and ad valorem taxes in a conjectural variation model of an oligopolistic market for a homogeneous good with potentially asymmetric firms. The formula is incorrect.[1] Given the recent increase in interest in cost pass-through, which bears directly on tax incidence, and in the conjectural variation model (see Weyl and Fabinger (2009) and Jaffe and Weyl (2012)),[2] and given also the potential significance of the error to empirical pass-through studies, it is worthwhile to derive the correct formula, which we do here.

In Section 2, we present the conjectural variation model and describe the error in D–O. In Section 3, we derive the correct formula and provide the conditions under which the D–O formula, despite the error, turns out to be correct. The significance of the error is discussed in Section 4.

2. The conjectural variation model with ad valorem and specific taxes

The N-firm conjectural variation model includes, for each firm i, a nonnegative *conduct parameter*, λ_i, that specifies the rate at which firm i expects total output to change per unit change in its own output.[3] The conduct parameter is usually interpreted as the "reduced form" coefficient determined by the equilibrium of an underlying repeated game, see Cabral (1995). Specifically, if q_i is the output of firm i, and Q is total industry output, then firm i conjectures that,

$$\frac{dQ}{dq_i} = \lambda_i. \tag{2.1}$$

When all $\lambda_i = 0$, market behavior is competitive. A value of $\lambda_i = 1$ for all firms corresponds to Cournot behavior, while in the symmetric case of identical cost functions $\lambda_i = N$ for all firms corresponds to market-share collusion.

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[1] D–O extends the analysis in Delipalla and Keen (1992) to the case of asymmetric firms. In the special case of symmetric firms, Delipalla and Keen (1992) derive the correct tax incidence formula.

[2] The conjectural variations model provides "a useful framework for empirical investigations into the exercise of market power and the 'competitiveness' of an industry" Church and Ware (2000, p. 273). See also Dixit (1986), Bresnahan (1989), and Church and Ware (2000) for interpretations and empirical uses of the conjectural variations model. More recently, see Majumdar et al. (2011) for empirical applications, and Jaffe and Weyl (2012) for a theoretical application, to merger review.

[3] Nonnegativity ensures that, in equilibrium, no firm's marginal cost exceeds the price.

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Given an ad valorem tax of v and a specific tax of σ, a profit-maximizing firm chooses q_i to maximize

$$[(1-v)P(Q)-\sigma]q_i-c_i(q_i), \tag{2.2}$$

where $c_i(q_i)$ is the firm's cost function, Q is the total market quantity, and $P(Q)$ is the inverse demand function. We assume throughout that all functions are differentiable and that $c'_i(q_i)\geq 0$ and $P'(Q)\leq 0$. Given the conjectures in Eq. (2.1), firm i's first-order condition for profit maximization is

$$(1-v)\left[P(Q)+\lambda_i P'(Q)q_i\right]-c'_i(q_i)-\sigma=0. \tag{2.3}$$

In equilibrium, each firm maximizes its profits given the output of the others. Hence, Eq. (2.3) holds for each firm i.[4] Since the effect on price of changing a specific tax can be derived from the effect on price from changing an ad valorem tax, we will henceforth focus on the latter.[5]

To derive their ad valorem tax incidence formula, Delipalla and O'Donnell, after dividing Eq. (2.3) by λ_i and summing over i, differentiate the resulting equation with respect to the tax, v. In the course of performing this comparative statics exercise, they evidently incorrectly assume that Eq. (2.1) is an identity.[6] Combining this error with the fact that $\frac{dq_i}{dv}=\frac{dq_i}{dQ}\frac{dQ}{dv}$, they evidently conclude that

$$\frac{dq_i}{dv}=\frac{1}{\lambda_i}\frac{dQ}{dv}, \tag{2.4}$$

and use Eq. (2.4) to substitute out all the dq_i/dv terms. This allows them to solve for dQ/dv and leads quite directly to their expression for dP/dv.[7]

That Eq. (2.4) need not hold can be seen by noting that $Q=\sum q_i$ implies that $\frac{dQ}{dv}=\sum\frac{dq_i}{dv}$. Therefore, if Eq. (2.4) were true, we would conclude that[8]

$$\sum\frac{1}{\lambda_i}=1, \tag{2.5}$$

which, of course, need not be true. For example, in the Cournot model, $\lambda_i=1$ for all i.

3. Tax pass-through in an oligopoly setting

If a tax is changed, possibly from zero, the pass-through is the percentage of the resulting change in tax revenue paid by consumers. Formally, the *pass-through for an ad valorem tax change from v_0 to v* is defined by,

$$\text{Pass-through}(v_0,v)=\frac{p(v)-p(v_0)}{vp(v)-v_0\,p(v_0)}, \tag{3.1}$$

where $p(v)$ is the equilibrium price of the good when the ad valorem tax is v.[9]

The numerator in Eq. (3.1) is the additional amount paid by the consumer per unit of the good purchased and the denominator is the additional tax revenue collected per unit purchased. As is standard, we say that there is *full-shifting* (of the tax) if the right-hand side of Eq. (3.1) equals 1, *undershifting* when it is less than 1, and *overshifting* when it is greater than 1.

The *pass-through at the point v_0* is defined by taking the limit of Eq. (3.1) as $v\rightarrow v_0$. Hence,

$$\text{Pass-through}(v_0)=\frac{p'(v_0)}{p(v_0)+v_0p'(v_0)}=\frac{d\log p(v_0)/dv}{1+v_0 d\log p(v_0)/dv}. \tag{3.2}$$

As in D–O, we henceforth assume that each λ_i is strictly positive so that division by λ_i is well-defined. However, all of our expressions have well-defined limits as any of the λ_i converge to zero and these limiting expressions are those that would result from solving the system when those λ_i are in fact zero in Eq. (2.3). In particular, results for the competitive case are obtained by considering the limit of our results as all the λ_i converge to zero.

Computing pass-through begins with the first-order condition, Eq. (2.3), which can be rewritten as

$$\frac{s_i}{\varepsilon(Q)}+\frac{c'_i(s_iQ)+\sigma}{(1-v)P(Q)\lambda_i}=\frac{1}{\lambda_i} \tag{3.3}$$

where each q_i is the equilibrium quantity produced by firm i, Q is total output in equilibrium, $s_i=q_i/Q$ is firm i's equilibrium market share, and $\varepsilon(Q)=-P(Q)/QP'(Q)$ is the (positive) elasticity of market demand evaluated at the equilibrium level of total output.

The equilibrium quantities, $q_i(v)$ and $Q(v)$, are functions of the ad valorem tax, v. In particular, $p(v)=P(Q(v))$. However, to keep the notation manageable, we will continue to write q_i and Q rather than $q_i(v)$ and $Q(v)$.

Differentiating Eq. (3.3) with respect to v and using $dQ/dv=(P(Q)/P'(Q))(d\log P(Q)/dv)$ yield

$$\begin{aligned}0=&\frac{1}{\varepsilon(Q)}\frac{ds_i}{dv}-\frac{\varepsilon'(Q)}{\varepsilon^2(Q)}\frac{s_iP(Q)}{P'(Q)}\frac{d\log P(Q)}{dv}\\&+\frac{c''_i(s_iQ)}{(1-v)P(Q)\lambda_i}\left(\frac{ds_i}{dv}Q+\frac{s_iP(Q)}{P'(Q)}\frac{d\log P(Q)}{dv}\right)\\&-\frac{P'(Q)}{P^2(Q)}\frac{\left(c'_i(s_iQ)+\sigma\right)}{\lambda_i(1-v)}\frac{P(Q)}{P'(Q)}\frac{d\log P(Q)}{dv}+\frac{\left(c'_i(s_iQ)+\sigma\right)}{P(Q)\lambda_i}\frac{1}{(1-v)^2}.\end{aligned}$$

Solving for ds_i/dv gives

$$\frac{ds_i}{dv}=\frac{a_i}{b_i}\frac{d\log P(Q)}{dv}-\frac{c'_i(q_i)+\sigma}{b_iP(Q)\lambda_i}\frac{1}{(1-v)^2} \tag{3.4}$$

where

$$a_i=\frac{c''_i(q_i)q_i\varepsilon(Q)+c'(q_i)+\sigma}{P(Q)\lambda_i(1-v)}-\frac{\varepsilon'(Q)}{\varepsilon(Q)}q_i$$

and

$$b_i=\frac{c''_i(q_i)Q}{P(Q)\lambda_i(1-v)}+\frac{1}{\varepsilon(Q)}.$$

At this stage, it is useful to introduce the following notation. Let

$$\eta_i(q_i,\sigma)=\frac{c'_i(q_i)+\sigma}{q_ic''_i(q_i)}$$

[4] We assume throughout that pure strategy equilibria exist and satisfy the firms' first-order conditions (namely Eq. (2.3)) with equality.

[5] See the Remark below for how to compute the former from the latter.

[6] But Eq. (2.1) is not an identity because firm i's conduct parameter λ_i merely specifies how firm i conjectures that other firms' quantities will react to *deviations* from i's equilibrium level output. In contrast, when conducting a comparative statics exercise – e.g., a change in the ad valorem tax, v – none of the q_i ever deviate from their equilibrium values and hence there is no opportunity for Eq. (2.1) to come into play.

[7] A detailed derivation of the pass-through formula in D–O is not provided. Instead it is stated (D–O p. 890) that the derived formula for dP/dv "…is immediate on applying the implicit function theorem to [the first-order condition]." As we will see, obtaining the correct formula is not so immediate.

[8] The maintained (but incorrect) assumption in D–O that Eq. (2.1) holds implies that dQ/dv is nonzero.

[9] The value of the specific tax is held fixed and so we suppress the dependence of the price on σ.