IMPERFECT COMPETITION AND THE SHIFTING OF OUPUT AND INPUT TAXES IN VERTICALLY-RELATED MARKETS*

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Abstract

We consider the impact of output and input taxes in vertically-related markets where the downstream industry is oligopolistic and the upstream sector competitive. We show that the shifting of a tax in each related market will depend on the degree of market power in the downstream market, the characteristics of the demand function, the nature of the production technology characterising the downstream industry cost function and the existence of increasing or decreasing returns to scale. Only in specific circumstances will the forward-shifting of an input tax be observationally equivalent to the backward shifting of an output tax.

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I. INTRODUCTION

It is well-known from the public finance literature that when markets are oligopolistic, the level of tax incidence following the introduction, or change in the level, of a tax differs from the case where markets are perfectly competitive. Specifically, depending on the degree of market power, together with the convexity of the demand function and the nature of the cost function, there can be either 'over-' or 'under-shifting'. Over-shifting is the outcome when the change in the final price is greater than the tax change, under-shifting being the case when the change in the price is less. The most notable papers that set out the basic issues in this area include Seade (1985), Katz and Rosen (1985), Dixit (1986), and Stern (1987) among others[1]. The focus of this paper differs from this existing literature as we deal with the shifting of output and input taxes in the context of a vertically-related market where the downstream stage is characterised as being oligopolistic with the upstream stage competitive. Shifting in this context therefore refers to the impact of a shock on price in the neighbouring market. For example, in dealing with an input tax originating in the competitive upstream market, we focus on forward-shifting i.e. the effect on price of the final good sold on the downstream oligopolistic market. In dealing with an output tax, we consider the impact on prices received by producers in the upstream competitive industry i.e. backward-shifting.

The impact of taxes on intermediate goods has received only limited in the public finance literature. Notable in this regard is the work of Bhatia (1986) who considers a range of taxes where the elasticity of substitution between intermediate inputs has an important role in determining the incidence of taxes. The work of Bhatia differs from other work on vertically-

[1] Recent extensions in this area include the comparison between specific and *ad valorem* taxes (Delipalla and Keen, 1992), allowing for product differentiation (Anderson *et al*., 2001) and asymmetric oligopoly (Dierickx *et al*., 1988). This list is not extensive. For an overview of the issues involved see Fullerton and Metcalf (2002).

linked markets that often assumes a Leontief (fixed proportions) technology. However, Bhatia assumes markets are perfectly competitive; in the set-up used in this paper, the downstream sector is assumed to be imperfectly competitive. Myles (1989) also deals with intermediate taxes allowing for imperfect competition. In this case, imperfect competition arises in the intermediate sector, and he also allows for non-constant returns to scale[2]. In the model presented below, imperfect competition arises in the downstream sector whose cost function can be characterised by returns to scale. As we show, the shifting of taxes will not only depend on whether the technology is one of fixed or variable proportions as was the focus of Bhatia but also on the degree of competition in the downstream market and presence of returns to scale as in much of the tax incidence literature. However, in comparing the incidence of each of the taxes applied in the related market, we show that the role for each of these factors has a differential effect on the forward and backward-shifting elasticities.

The paper is organised as follows. In section II, the modelling framework is introduced and the forward and backward elasticities are derived. Section III is the mainstay of the analysis where the key determinants of, and the difference between, these elasticities are considered. In section IV, we summarise and conclude.

II. THEORETICAL FRAMEWORK

In the theoretical framework presented below, firms are assumed to produce a homogeneous product and pursue quantity-setting strategies. To account for the technology that links the downstream industry with the upstream one, we assume that the downstream industry uses

[2] It should be noted that the analysis here is positive rather than normative. We do not deal with the issue as to whether taxes should or should not be imposed in intermediate goods. For a discussion of this issue, see Diamond and Mirlees (1971) and Myles (1989). Moreover, we focus solely on the effects on prices in related markets and do not deal with additional issues associated with tax incidence.

two variable inputs each supplied from competitive industries. Capital is assumed to be fixed in the short-run. This specification is consistent with short-run equilibrium with capital being a quasi-fixed factor such that firms can vary only the variable inputs in maximising profits[3]. Further, the industry cost function is characterised by a variable proportions technology which allows for potential substitutability between (the variable) inputs. However, while the downstream industry is modelled as being oligopolistic, it is assumed that it cannot exert oligopsony power vis-à-vis the supply of inputs. Finally, firms' interactions are modelled through the use of conjectural variations. While the theoretical inadequacies of this approach are duly acknowledged, it nevertheless allows us to tie the theoretical framework directly with the econometric measures of market power which have typically measured conjectural elasticities (see Bresnahan (1989) for a review of early work in this area). As Karp and Perloff (1989) note, empirical estimates of this parameter can be interpreted as an index of market power[4].

The inverse demand function of the final product is given by:

(1) $$R = h(Q, T_R)$$

where R is the price of the final product and Q is the level of the downstream industry output. T_R is the (specific) tax on the final good.

The industry production function uses two variable inputs, (in combination with capital assumed to be a quasi-fixed factor) and is given by:

(2) $$Q = f(A, M; \overline{K})$$

[3] As Morrison-Paul and Siegel (1999) show from their empirical work, returns to scale mainly arise in the short-run, the impact of capital adjustment being relatively minor.

where A and M represent the inputs from upstream industries A and M respectively with capital inputs being fixed in the short-run. The production function is assumed to be homogeneous of degree ρ.

The input supply functions for A and M, in inverse form, are:

$$P = k(A, T_A) \qquad (3)$$

$$W = g(M) \qquad (4)$$

where P and W are the prices of A and M. Both upstream sectors are assumed to be competitive. We assume that the input tax is imposed in the A sector. The variable T_A is the (specific) tax on the input good A.

In the downstream sector, firms maximise profits. For a representative firm, the (short-run) profit function is given by:

$$\pi_i = (R(Q)\, Q_i - C_i(P, W, Q_i; \overline{K})) . \qquad (5)$$

The first-order condition for profit maximisation gives:

$$R + R' Q_i (\theta_i) - \partial C_i / \partial Q_i = 0 \qquad (6)$$

where $\theta_i (= \partial Q / \partial Q_i)$ is the conjectural variation parameter for firm i. For $\theta_i = 0$, the market is competitive while $\theta_i = 1$ implies a monopoly or collusive outcome. Assuming equal-sized *n*-firms with identical cost structures and summing over *i* firms (noting that $Q = \sum_i^n Q_i$), (6) can be simplified as:

$$R = \lambda MC \qquad (7)$$

where

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[4] Many of the (relatively few) empirical studies of incidence have used the conjectural variation approach including Karp and Perloff (1989) and Barnett *et al*. (1995).

$$\lambda = \frac{n\eta}{n\eta - \theta}$$

which reflects the industry mark-up of price over cost and can be described as the industry mark-up coefficient. θ is the aggregate conjectural variation or market power parameter and MC is the industry-level marginal cost. As is common with industrial organisation models of this type, there are notable assumptions to make about this process of aggregation most notably that, in aggregating the conjectural elasticities, it is assumed that the conjectural variation parameters are identical across all firms.

In deriving the shifting elasticities, we shall consider the impact of the output and input taxes separately. The forward-shifting elasticity relates to the effect on the final good price resulting from an input tax originating in the upstream market; the associated impact on the upstream A sector arising from the output tax in the downstream industry is the backward-shifting elasticity.

(a) Forward Shifting Elasticity

The procedure for deriving the transmission elasticity is to use equations (1) to (7) and solve for changes in the endogenous variables following a shift in the A sector supply function given by T_A. The forward elasticity is represented as τ which is given by:

(8) $$\tau = \frac{\alpha\rho\ (1 + \gamma\sigma)}{(\rho + \alpha\gamma\sigma)\ ((1 + \mu)\ \rho - \eta\ (\rho - 1)) + \beta\gamma\eta}$$

where α and β are output elasticities with (α + β = ρ); ρ is the (short-run) returns to scale measure with ρ greater (equal, less) than 1 representing increasing (constant, decreasing) returns to scale, σ is the elasticity of substitution between A and M inputs, γ is the inverse elasticity of supply of M inputs, η is the industry elasticity of demand and μ is the elasticity of the industry mark-up where μ=ω(θ/nη-θ) with ω representing the change in the elasticity of demand for a given change in the price of the final good.

Noting that α equals $s_A\rho$ and β equals $s_M\rho$ where s_A (s_M) is the share of A (M) inputs in the industry cost function, equation (8) can be re-written as[5]:

$$(9) \qquad \tau = \frac{s_A \rho\ (1 + \gamma\sigma)}{(1 + s_A \gamma\sigma)\ ((1 + \mu)\ \rho - \eta\ (\rho - 1)) + (1 - s_A)\gamma\eta}.$$

(b) Backward Shifting Elasticity

The backward-shifting elasticity following the output tax which shifts the demand function is given by:

$$(10) \qquad \upsilon = \frac{\varepsilon(1+\mu)(1+\gamma\sigma)}{[s_A\varepsilon + (1-s_A)\gamma + \varepsilon\gamma\sigma - (\rho-1)((1-s_A)\varepsilon\sigma + s_A\gamma\sigma + 1)]}$$

where ε is the inverse of the supply elasticity in the upstream market and the remaining parameters in (9) are defined as for (8).

III. DETERMINANTS OF SHIFTING IN VERTICALLY-LINKED MARKETS

The focus in this section is on highlighting the factors that influence the shifting of output and input taxes in this vertically-related set-up and the varying impact key factors have in determining the difference between the forward and backward elasticities. The key point to note is that only when markets are characterised by perfect competition and a fixed proportions technology are the two elasticities observationally equivalent. Moreover, the role of key determinants such as the nature of the technology linking the two sectors, market power and the returns to scale differs depending on whether we are considering the impact of an output or input tax.

(a) The Benchmark Case

We define the benchmark case as one with perfect competition ($\mu = 0$) and (short-run) constant returns to scale ($\rho = 1$) and a fixed proportions technology ($\sigma = 0$). Focus first of

[5] For convenience, we (implicitly) assume that the factor share of capital is zero which permits a direct interpretation of the ρ parameter. See also footnote 3 relating to the importance of short-run factors in determining returns to scale.

all, on the forward elasticity arising from a supply shock in the upstream market. From (9) we have:

(11) $$\tau = \frac{s_A}{(1 - s_A)\gamma\eta} .$$

For a relatively elastic supply function for M inputs ($\gamma \to 0$), $\tau \to s_A$ i.e. the value of the forward elasticity will be close to the share of A inputs in the industry's cost function. With $\gamma = 0$, $\tau = s_A$, the incidence elasticity equals the share of the A inputs in the industry's cost function.

With perfect competition, (short-run) constant returns to scale and fixed proportions, the corresponding back-shifting elasticity arising from an output tax in the downstream market is given by:

(12) $$\nu = \frac{\varepsilon}{s_A\varepsilon + (1 - s_A)\gamma} .$$

Again, with $\gamma \to 0$, the back-shifting elasticity is equal to the reciprocal of the share of the A input in the industry cost function. So, for $s_A = 0.5$, the forward shifting elasticity equals 0.5 while the back-shifting elasticity equals 2.

Given these benchmark cases, for an input tax arising in the upstream A market, we define 'under-shifting' as the case where forward-shifting effect is less than the share of the A input in the industry cost function. Correspondingly, 'over-shifting' arises when the change in the retail price is greater than the change in the A price arising from the input tax. In the case of the output tax, under-shifting arises when the change in the A price is less than the reciprocal of the share of the A input in the industry cost function and over-shifting is the case where the change in the A price is correspondingly greater.

(b) Fixed versus Variable Proportions

Consider the role of technology characterising the downstream industry cost function. Since, with few exceptions, most studies of tax shifting do not focus on the link between vertically-related markets, the role of technology plays no explicit role. The role of technology arises through assumptions concerning the elasticity of substitution between A and M as given by σ, with $\sigma = 0$ being equivalent to a fixed proportions or Leontief technology and $\sigma > 0$ representing a variable proportions technology. Assuming a perfectly competitive market with constant returns to scale in the short-run, the forward shifting elasticity allowing for a variable proportions technology is given by:

(13) $$\tau_c = \frac{s_A(1 + \gamma\sigma)}{(1 + s_A\gamma\sigma) + (1 - s_A)\gamma\eta}$$

with the corresponding back-shifting elasticity being given by:

(14) $$\nu = \frac{\varepsilon(1+\gamma\sigma)}{s_A\varepsilon + (1-s_A)\gamma + \varepsilon\gamma\sigma}\ .$$

The role of technology on tax shifting can be shown most easily by choosing appropriate parameter values for the variables in (13) and (14) and choosing alternative values for σ. Figures 1 and 2 show the impact of increasing σ.

FIGURES 1 AND 2 SHOULD BE ENTERED HERE OR LATER

Figure 1 shows the role that technology plays with respect to the role of an input tax. In the benchmark case, $\tau = 0.5$. With $\sigma = 0$, but allowing for a positive value for γ, the forward shifting elasticity is close to this ($\tau = 0.49$). As σ increases, the shifting of the input tax becomes greater, with sufficiently high elasticities of substitution leading to 'over-shifting' given the definition of our benchmark case. This arises since, with a negative supply shock, the price of A will rise; but with $\sigma > 0$, the price of M rises too leading to over-shifting.

While in the input tax case the role of the degree of substitution is to increase tax shifting, with an output tax, the role of σ is to reduce it. For example, with a reduction in the output tax, this would increase the derived demand for the upstream input. However, with the possibility of substituting into other inputs, the price of A rises but is diluted due to $\sigma > 0$. This is clear from Figure 2 which shows that as σ rises, the degree of under-shifting relative to the benchmark case, increases.

(c) Role of Market Power

Many of the studies of incidence in the public economics literature have been concerned about the role of market power. As known from Seade's (1985) paper, the change in marginal cost can, depending on the shape of the demand function, cause under- or over-shifting. The same outcome arises in the analysis here for both the forward and backward shifting elasticities.

Consider for example the impact of an input tax that affects the downstream industry's costs. In the absence of market power, the impact of this change arises only through the cost function which, as we have noted above, will depend on whether it is characterised by a fixed or variable proportions technology. However, in the presence of market power, the impact of an input tax will depend on not only how it affects the firm's costs but also how firms change their mark-ups. The change in the mark-up is also dependent on the specific form of the demand function. Specifically, to take the case of an input tax by way of example, the impact of the on the industry mark-up is given by:

$$\mu = \frac{d\ln\lambda}{d\ln C} = \frac{d\ln\lambda}{d\ln\eta}\frac{d\ln\eta}{d\ln C} = \left(\frac{\theta}{n\eta - \theta}\right)\frac{d\ln\eta}{d\ln C}.$$

The change in the mark-up therefore does not only depend on the degree of market power (θ) and the number of competing firms (n) but also the change in the elasticity of demand. Consider two alternative functional forms for the demand function. In the log-linear case, $d\ln\eta / d\ln C = 0$. In this case, despite the existence of market power, the shifting of the input tax (assuming short-run constant returns to scale) will equal the tax shifting elasticity that would arise in perfectly competitive markets with the only issue being the characteristics of the technology that links the upstream and downstream sectors. In the linear demand case, $\partial\ln\eta / \partial\ln C = 1 + \eta$. In this case, the impact of the role of market power also depends on the shape of the demand function.

The tax shifting elasticities in each case are now found by returning to (9) and (10) and setting $\rho = 1$, to give:

(15) $$\tau = \frac{s_A(1+\gamma\sigma)}{(1+s_A\gamma\sigma)(1+\mu)+(1-s_A)\gamma\eta}$$

and

(16) $$\nu = \frac{\varepsilon(1+\mu)(1+\gamma\sigma)}{s_A\varepsilon+(1-s_A)\gamma+\varepsilon\gamma\sigma} \ .$$

With an increase in market power being given by higher values for θ, for the linear demand case, a rise in θ will reduce the forward shifting elasticity arising from an input tax and increase the back-shifting impact on upstream prices arising from an output tax. This is most easily seen by choosing representative values for the parameters in (15) and (16) and varying the level of θ. The impact on the elasticities arising from a change in θ is shown in Figure 3.

FIGURE 3 SHOULD BE ENTERED HERE OR LATER

As expected the back-shifting elasticity increases as market power rises leading to increasingly higher levels of over-shifting of the output tax, with under-shifting arising in the case in the input tax. It is also worth noting that the impact of market power differs between these two cases, market power having a relatively greater impact on the back-shifting elasticity.

(d) Returns to Scale

As noted above, the role of returns to scale should not be separated from the estimate of market power (Morrison-Paul and Siegel, 1999). In this section, we consider the role of returns to scale on the tax shifting elasticities. With a variable proportions technology and market power, the elasticities inclusive of returns to scale are given by equations (9) and (10) for the forward and backward elasticities respectively. As with the previous examples, to show the impact of returns to scale, we choose representative values for the parameters in (9) and (10) and simulate with representative values for the returns to scale parameter i.e. $1 > \rho \geq 1$ with $\rho < 1 (\rho > 1)$ representing decreasing (increasing) returns to scale respectively. The impact of alternative values of ρ on the tax shifting elasticities are shown in Figure 4.

FIGURE 4 TO BE INSERTED HERE OR LATER

For $\rho = 1$, we have the constant returns to scale case which gives (since we also allow for some degree of market power $(\theta = 0.25)$) tax shifting elasticities below the perfect competitive case for the forward elasticity and above the benchmark case for the back-shifting elasticity. In the case of the forward-shifting elasticity, increasing returns to scale offsets the impact of market power. Note that, for a given level of market power, if the short-run scale parameter is sufficiently large, over-shifting can arise even with market power and a linear demand curve. However, in the case of the back-shifting elasticity, increasing returns to scale reinforces the effect of market power as $\rho > 1$ leads to a further degree of over-shifting. It can also be seen from Figure 4 that the marginal effect of the returns to scale parameter is greater in the back-shifting elasticity compared to the forward elasticity.

IV. SUMMARY AND CONCLUSIONS

This paper has focused on the shifting of taxes of supply in vertically-related markets where the downstream sector is characterised by imperfect competition. Although there is a large and developing literature on incidence among public finance economists, the typically focus on one source of the exogenous change type of tax. With few exceptions, most research does not consider the vertically-linked nature of markets and how tax shifting compares between downstream and upstream markets. The advantage of the framework used in this paper is that the shifting of demand and supply shocks can be considered within the same unified framework. Moreover, the measure of shifting has been expressed in a general elasticity form which will make it relatively easy to interpret given outside estimates of the parameters of importance.

There are several additional advantages to considering shifting in this vertically-related set-up. First, in recognising the explicit links between the upstream and downstream sectors, we can allow for the role of the technological characteristics of the downstream industry cost function to play a role. We have also generalised this to exhibit the possibility of increasing or decreasing returns to scale. Second, by considering output and input taxes in the same framework, it is possible to consider the marginal effect of key aspects of market structure. As shown, market power and returns to scale have a much greater marginal impact in influencing the back-shifting elasticity compared to the forward shifting elasticity.

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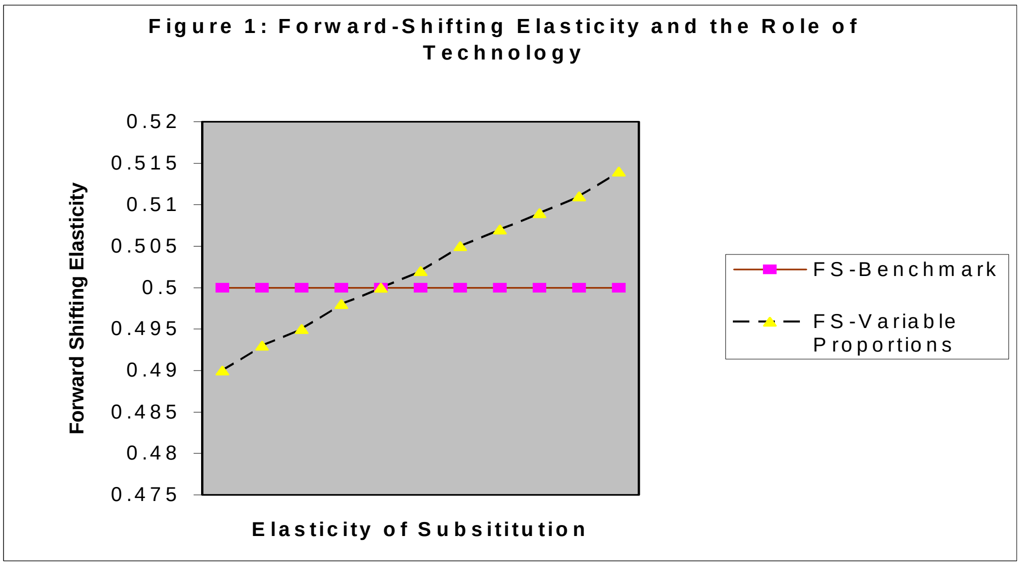


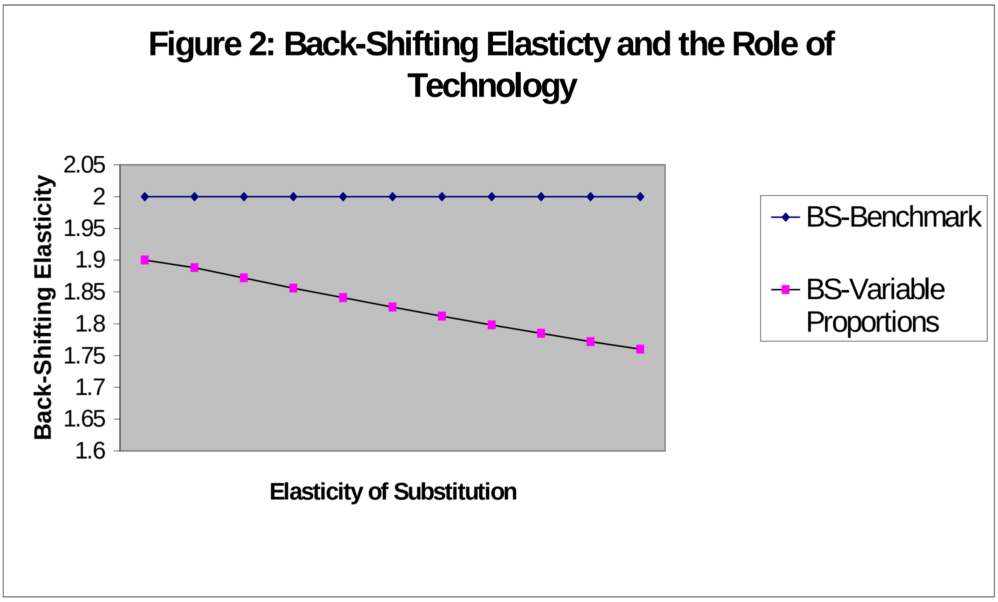
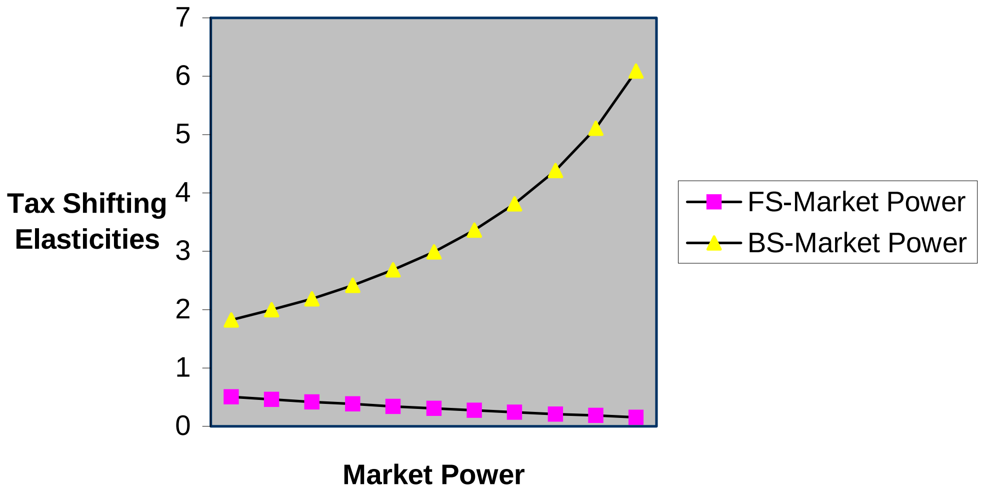


Figure 3: Impact of Market Power on Tax Shifting



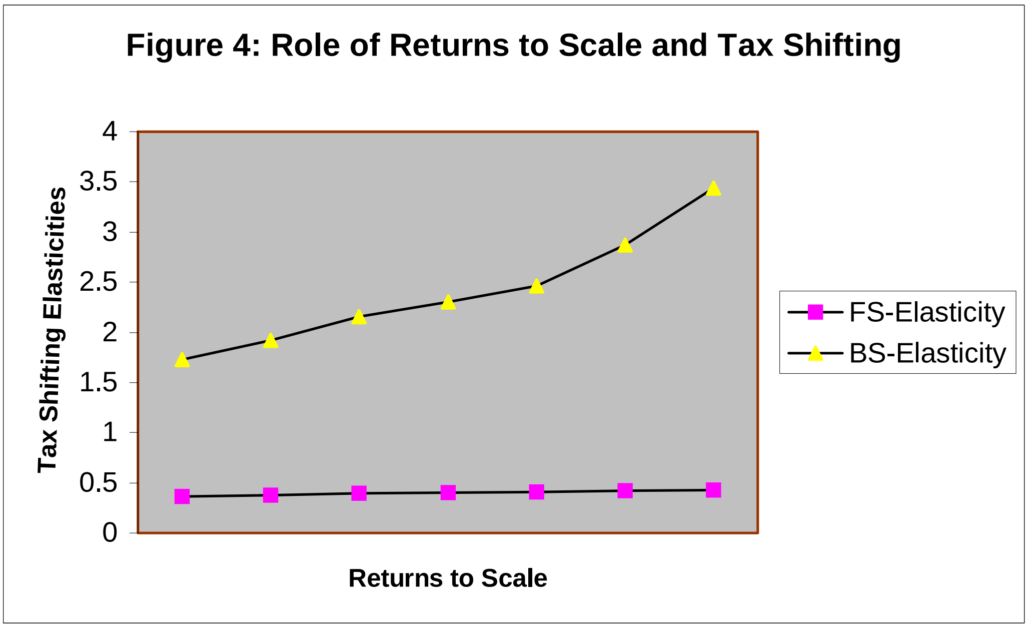


Figure 4: Role of Returns to Scale and Tax Shifting
Tax Shifting Elasticities
4
3.5
3
2.5
2
1.5
1
0.5
0
Returns to Scale
FS-Elasticity
BS-Elasticity