Subsidizing (And Taxing) Business Procurement

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Abstract

This paper studies the effect of a subsidy (or tax) on a market where a downstream manufacturer uses a competitive tender to procure inputs from upstream suppliers. Subsidizing input production can result in input price decreases that are greater than the effective decrease in marginal costs. That is, overshifting occurs. When the size of the subsidy is not too large, the downstream firm can enjoy an increase in profits greater than the government expenditure on the subsidy. A relatively weak sufficient condition for these results to hold is that suppliers earn a positive profit margin on the marginal unit sold, before taking into account any subsidy payment. Stronger sufficient conditions, tailored to each result, are provided.

Keywords: Subsidy, Tax, Overshifting, Pass-Through, Imperfect Competition, Vertical Market, Procurement, Auctions, Competitive Tender

JEL Codes: H22, H25, F12, F13, D44, L13

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1 Introduction

In 2004 a new round of conflict erupted between the USA and EU over subsidy payments in the commercial jetliner industry. The USA alleged that the EU was improperly supporting Airbus, while the EU made a similar counterclaim with respect to payments made to Boeing (see Carbaugh and Olienyk (2004) for an overview of this long-running dispute). An element of the EU claim is that large subsidy payments (mainly in the form of tax breaks) were made to Boeing suppliers. Understanding how these subsides work in an imperfectly competitive vertical market structure is crucial to deciding the extent to which these subsidies are *de facto* subsidizing Boeing as the downstream firm.

It is common practice for governments to give industry specific assistance and the extent of this industry assistance can be large. In the context of the Boeing-Airbus dispute, the EU alleges that Boeing has received 23 billion dollars in subsidies since 1992, while the USA alleges that Airbus has received 15 billion dollars over the same period. In 1995 the Congressional Budget Office estimated that $27.9 billion was paid by the US federal government, via direct spending programs, to industry, a sum which does not include subsides in the form of tax concessions (Congressional Budget Office 1995).[1] At the state level, industry support can be particularly directed: in 2005 the Ohio governor announced a two year support plan for the automotive parts and manufacturing industry comprising $371 million in expenditures (Taft 2005). Such measures are not unique to the US: Australia is estimated to have spent A$730 million assisting the automotive industry in 2000-01, with the recipients of payments evenly split between manufacturers and parts suppliers (Productivity Commission 2002); the UK has spent £560 million supporting the shipbuilding industry via *ad valorem* subsidies administered through the Shipbuilding Intervention Fund (Allen 2003), thus subsidizing the ships used as inputs by shipping companies.

When these subsidies are being provided to suppliers of inputs, benefits from these payments will flow, via the input market, to downstream firms. Often this input market is characterized by a competitive tendering process in which several suppliers bid for a supply contract. This paper asks how subsidies affect markets in which manufacturers procure inputs from suppliers using competitive tenders. The model presented here reveals that the impact and incidence of a subsidy (or tax) on business procurement will differ considerably from its impact in other markets with imperfect competition.

In the model in this paper the competitive tender process is modelled as a first price auction, as

[1] The CBO report suggests that subsidies recorded as federal government tax expenditures would account for at least this much again.

first introduced by Vickrey (1961). The competition between input suppliers induced by this tender differs significantly from the results suggested by standard cournot and bertrand frameworks. If the supplier earns a positive profit on the extra units supplied, the price decrease induced by an ad valorem or specific (unit) subsidy is greater than its impact on marginal costs. In the commonly used case of constant marginal costs this is always the case, so long as demand is downward sloping That is, we see overshifting of the subsidy. Somewhat surprisingly, a lump sum subsidy to upstream suppliers is observed to have a distortionary impact on prices.

The incidence results in this paper are novel in that the demand conditions required for overshifting in other settings are not required. It is well known that subsidy (or tax) overshifting can occur in other models with imperfect competition. Katz and Rosen (1985), Stern (1987), Dellipala and Keen (1992), Keen (1998) and Besley (1989) all note the possibility of this effect for the cournot model, while Anderson et al (2001) provides conditions for this effect in model of differentiated products bertrand. These earlier models required a condition analogous to demand being steeper than marginal revenue.[2] This rules out many commonly used demand curves, including linear demand. In the competitive tendering environment, with constant marginal costs, all that is required for overshifting is a downward sloping demand curve. As suppliers' cost functions become steeper the implicit restrictions on demand do become stronger.

Following from the overshifting result, a welfare result is derived for the distribution of the benefits from the subsidy, when procurement is conducted using a competitive tendering procedure. Even if a unit (specific) or ad valorem subsidy is paid to suppliers all the benefits flow downstream to the manufacturer (the procurer) or consumers. More importantly, the total benefit to the manufacturer alone can be greater than the government expenditure on the subsidy, reflecting a possible benefit from distorting interaction between suppliers and the procuring firm. Anderson et al (2001) show that firms may benefit from a tax if overshifting occurs, which is a similar result in spirit, although, again, the result presented in this paper requires fewer restrictions on demand. Additionally, in the competitive tendering environment with constant marginal costs, it is shown that for *any* procurer-supplier configuration there is a subsidy for which the profit increase for the downstream monopolist is greater than the government's expenditure on the subsidy.

The results described to this point rely on two important sets of assumptions: first, that the downstream firm is in a monopsony position in the sense of being able to dictate the terms of the competitive tender; and second on the specification of the suppliers' costs. These costs are modelled as having a fixed and variable component. The fixed cost is privately known and independently

[2] In the cournot model, if demand is given by $p(q)$ what is required is $-p'(q) < p''(q)\,q$

and identically distributed across bidders.[3] Each supplier's variable cost is commonly known and convex. Heterogeneity across firms' variables costs is accommodated by the model.

Lastly, it is noted that the nature of the procurement mechanism will change the magnitude of the incidence of a subsidy or tax, despite private information about costs being identically and independently distributed and firms being risk neutral, suggesting (at first glance) that the revenue equivalence theorem would make all mechanisms equivalent. The presence of concave profit functions induces behavior akin to risk aversion on the part of the downstream procurer which means that the benefit from a subsidy can change with the variance in the bids induced by the procurement mechanism.

The central contribution of this paper is to show that in a competitive tendering environment tax and subsidy overshifting occurs under very different conditions as compared to other models of imperfect competition. It is shown that this has a significant impact on incidence. The analysis is mostly conducted using subsidies since the results on incidence are more striking in this context. A full set of results for taxation is also supplied.

Empirical work by Harris (1987), in the context of cigarettes, and Besley and Rosen (1998), across a range of specific consumer products, find evidence of sales and excise tax overshifting. For instance, Besley and Rosen find that raising 10¢ per unit in tax revenue, increases the price of boys' underwear by more than 20¢.[4] The contribution of this paper to empirical work is to point out that the structure of interactions between firms in the supply chain can be just as, or even more, important than the elasticity of demand in assessing the likelihood of a tax or subsidy leading to overshifting.

The rest of the paper is structured as follows: Section 2 describes the modelling environment; Section 3 sets out the competitive tendering (auction) model and its relationship to the vertical market structure. The latter part of this section shows the basic comparative static results on overshifting and welfare. Section 4 considers subsidies to the downstream monopolist rather than the upstream suppliers. Section 5 discusses the relationship to taxation. Section 6 shows how to incorporate other auction formats. Finally, section 7 concludes.

[3] The i.i.d assumption is used for ease of exposition. The only thing that is needed, in the first price auction setting, is that each bidder's information rent be computable.

[4] Poterba (1996) conducts a similar study to Besley and Rosen, but with more aggregated data, and cannot reject the hypothesis of full shifting of sales taxes from firms to consumers.

2 The Environment

A downstream monopolist requires one unit of an input to manufacture one unit of output. Inputs may be supplied by any of n upstream suppliers. Each unit of input is purchased at some cost c.

The Downstream Market. The monopolist faces a demand curve $D(p)$ where $D'(p) < 0$. The profit of the monopolist is $\Pi^m = D(p)(p-c)$ where c is the price at which inputs are sourced. The monopolist chooses a price p to maximize profit, given the cost of inputs. The solution is a price, $p_m(c)$, where $p_m'(c) > 0$,and a quantity $q_m(c)$. The monopolist's first order condition is assumed to have a unique solution. Since there is a 1:1 relation between inputs and output this gives an induced demand for inputs which is assumed to satisfy the following properties.

> Assumption 1: The induced demand for inputs given by $q_m(c)$ satisfies the following properties:
> (a) $q_m'(c) < 0$; and
> (b) $q_m'(c) < -\frac{1}{2}q_m''(c)\,c$;

Property (b) is sufficient for a critical point of $q_m(c)\,c$ to be a global maximum. The downstream market is assumed to be a monopoly for ease of exposition. The re-interpretation of $D(p)$ as a residual demand curve admits a variety of other market structures.[5] The more important assumption is that the monopolist is a monopsonist, in the sense of being able to dictate the terms of the competitive tender, in the market for inputs.

The monopolist invites input suppliers to engage in a competitive tender for a supply contract. The supply contract allows the monopolist to buy as much of the input as is required from the supplier at a contracted per-unit price. This contract is awarded to the supplier with the lowest per-unit price.

The Upstream Market. The cost structure of each supplier is given by a differentiable cost function, $\mu_i(q)$, such that $\mu_i'(q) > 0$ and $\mu_i''(q) \geq 0$, and a firm specific fixed cost θ_i. $\mu_i(q)$ is common knowledge to all market participants while θ_i is private information known only to supplier i. The distribution of θ_i is given by $F(\theta_i)$, with support $\theta_i \in \left[\underline{\theta}, \overline{\theta}\right] \subset [0, V(c^*)]$ where $V(c^*) = \max_c q_m(c)\,c - \mu_i(q_m(c))$.[6] $F(\theta)$ is common knowledge. Hence, there are n suppliers who are *ex*

[5] For instance, if the downstream firm had a competitor who used different suppliers (as is the case for Boeing vis-a-vis Airbus) $D(p)$ would be reinterpreted as the residual demand from a cournot or differentiated products bertrand model, depending on the model of competition. If the suppliers were shared, then, depending on the exclusivity or duration of the contracts, it may be necessary to take into account the downstream externality implicit in offering a particular input price. This would likely involve an extension of the auction with externalities considered by Jehiel, Moldovanu and Stacchetti (1996).

[6] This ensures all potential suppliers wish to bid in the tender.

ante identical with their costs θ being identically and independently distributed draws from $F(\theta)$. Suppliers' profits, conditional on winning the tender, are given by $\Pi^s = q_m(c)\,c - \mu_i(q_m(c)) - \theta_i$. Π^s is assumed to be concave.[7]

3 Procurement through competitive tendering

The tender process is modelled as a first price sealed bid auction. At the start of the game the monopolist issues a request for quote to each potential supplier, suppliers then respond with a quote (a price per unit of input), the monopolist then sources inputs from the lowest cost supplier, chooses a quantity to supply to the product market and engages in production. Finally, payoffs are realized. The supply contract arising from the tender allows the monopolist to buy as much of the input as is required from the supplier at a contracted per-unit price.[8]

3.1 Analysis

The equilibrium in the input market, without any subsidy or tax, is considered first. The bidding problem of each supplier differs from that in a standard auction model in that the bid entered by supplier i, c_i, does not enter linearly into the suppliers payoff function. Recall that, conditional on winning the supply contract, the profit of a supplier i is given by

$$\Pi_i^s(\theta_i) = q_m(c_i)\,c_i - \mu_i(q_m(c_i)) - \theta_i$$

First observe that $c^* = \arg\max_c q_m(c)\,c - \mu_i(q_m(c_i))$ is the highest bid that any bidder would be willing to submit. Bidding higher than c^* is not optimal for any bidder since $c > c^*$ lowers both the probability of winning the procurement contract and the profit from doing so, relative to c^*. This means that the relevant region for c is $c \in [0, c^*]$. Recall that $V = q_m(c)\,c - \mu_i(q_m(c_i))$, the suppliers *ex post* profit, before fixed costs, conditional on actually winning the supply contract. Since $V = q_m(c)\,c - \mu_i(q_m(c_i))$ is strictly increasing and continuous in this region, there is a

[7] See Tirole (1988) for a discussion of necessary and sufficient conditions

[8] This contractual form is known as a requirement (or output) contract. These contracta are common in business-to-business procurement and a large legal literature, starting with Havighurst and Berman (1932), has commented on the legal issues that arise from using them (see Farnsworth (1990) or Macaulay et al (2003) for a summary). The cases cited therein cover a wide range of manufacturing industries including: the supply of coal to power stations, paper manufactring, oil refining, propane manufacturing, liquor distribution, sand mining, auto parts supply, aircraft manufacturing, the supply to limestone to an asphalt plant and the supply of laboratory equipment. Mortimer (2004) documents the use of requirement (output) contracts by movie studios.

one-to-one correspondence between c and $V(c)$ for $c \in [0, c^*]$.[9]

This correspondence between V and c means that we can simply treat V_i as the object of supplier i's choice. The resulting objective function is:

$$\max_{V_i} \quad (V_i - \theta_i) \Pr \left[V_i < \min_{j \neq i} V_j \right] \tag{1}$$

This is a standard problem equivalent to solving for the equilibrium bids in a first price sealed bid auction (see Krishna (2002) for more details). The supplier chooses a bid that optimizes the trade-off between the *ex-post* profit from winning, $(V_i - \theta_i)$, which is increasing in V_i and the probability of winning, which is decreasing in V_i. This equilibrium bid results in a margin between the fixed cost θ_i and the bid V_i called the information rent. In this setting, the information rent accruing to any bidder is a function of their fixed cost and the distribution of their competitors' fixed costs.

3.2 Analysis with subsidies

Three forms of subsidy (or, with a sign change, tax) are considered. The level of subsidy is denoted t. The first form of subsidy is a lump sum payment invariant to the amount of input provided. This lump sum subsidy changes the suppliers' payoff function to

$$\Pi^s(\theta_i) = q_m(c_i)\, c_i - \mu_i(q_m(c_i)) + t - \theta_i \tag{2}$$

Since the value of the subsidy is common knowledge, holding all prices constant, it has the effect of increasing the expected value of the contract to suppliers by the full extent of the subsidy. In equilibrium, however, since the distribution of fixed costs are unaffected, the information rents accruing to suppliers are unchanged from those in equation (1). As a consequence, to offset the effect of the subsidy, c_i is reduced so that $q_m(c_i)\, c_i - \mu_i(q_m(c_i))$ is decreased by t.[10]

> **Result 1:** *In this competitive tendering environment, a lump-sum subsidy paid to upstream suppliers will distort input prices and output .*

Competition between suppliers allows the lump sum subsidy to be reflected in the input prices offered to the monopolist, which, in turn, has an effect on the monopolist's output decisions.

[9] Recall, V is concave which means V is strictly increasing in this region. Since $\theta \in [0, V(c^*)]$, no bids below 0 would be made as these attract negative profits.

[10] A technical issue is raised when the subsidy is large enough to encourage suppliers to charge a negative price. This is problematic as free disposal of inputs on the part of the downstream firm can turn this situation into a money pump. If the downstream firm has free disposal then it makes sense to limit c such that $c \geq 0$. This would truncate the bid distribution and affect equilibirum. Since this case, does not seem relevant in an applied sense, it is assumed that the subsidy is not so large as to invite this problem.

A specific (unit) subsidy is also considered. This specific subsidy changes the suppliers' payoff function to

$$\Pi^s(\theta_i) = q_m(c_i)(c_i + \tau) - \mu_i(q_m(c_i)) - \theta_i \tag{3}$$

With the specific subsidy, V changes to $q_m(c_i)(c_i + \tau) - \mu_i(q_m(c_i))$. The analysis proceeds as in the case with no subsidy, with the information rent unaffected by the subsidy. The information rents are unaffected because nothing has changed the distribution of private information or the intensity of competition between the suppliers. In other words, the representation of the bidders' problem in equation (1) is unchanged. However, the cost of inputs to the monopolist is affected. Since V is unchanged (as the information rents are unchanged), the subsidy must have decreased the per unit cost of inputs, c, and increased output $q_m(c)$.[11]

Lastly, an *ad valorem* subsidy is considered. This *ad valorem* subsidy changes the suppliers' payoff function to

$$\Pi^s(\theta_i) = q_m(c_i)\, c_i(1+t) - \mu_i(q_m(c_i)) - \theta_i \tag{4}$$

The mode of analysis is similar to that used for the specific subsidy, adjusted to account for the multiplication of revenue by $(1+t)$. Again, the information rents of the supplier do not change (as the informational asymmetry is unaffected), but the per unit price bid does change.

Figure 1 shows the relationship between the per unit price, c_i, and V_i with, and without, a subsidy. It makes the simplifying assumption of a constant marginal cost of μ. When $V_i = q_m(c_i)(c_i - \mu)$ there is no subsidy. Since all bids of c_i must be to the left of c^* the 1:1 correspondence between c_i, and V_i is immediately apparent.

With the introduction of a specific subsidy $V(c_i)$ changes from $q_m(c_i)\, c_i - \mu_i(q_m(c_i))$ to $q_m(c_i)(c_i + \tau) - \mu_i(q_m(c_i))$, while an *ad valorem* subsidy changes $V(c_i)$ to $q_m(c_i)\, c_i(1+t) - \mu_i(q_m(c_i))$. Taking $\overline{\theta}$ as an illustration, the equilibrium bid decreases from $c(\overline{\theta})$ to $c_{SS}(\overline{\theta})$ under a specific subsidy of

[11] In the case of the specific and ad valorem subsidies it is assumed that a unique global maximum of $q_m(c)(c - \mu + \tau)$ exists. If $q''_m(c) > 0$ this amounts to assuming that t is not too large. Otherwise there is no restriction.

τ per unit and to $c_{AVS}\left(\overline{\theta}\right)$ with an *ad valorem* subsidy at rate t.

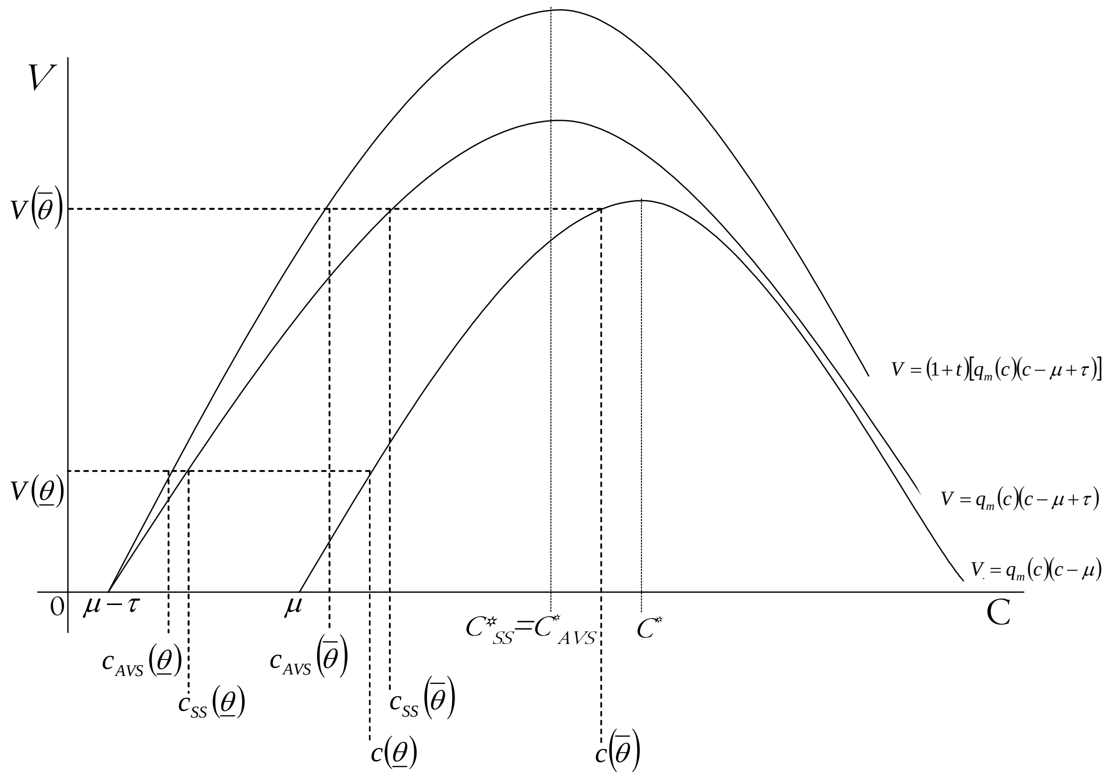

Figure 1: The relationship between c_i and V_i, with, and without, a subsidy.

[The subscript AVS indicates an ad valorem subsidy; the subscript SS indicates a specific subsidy; the lack of a subscript indicates the lack of a subsidy.]

3.3 Induced input price changes

The input price changes induced by the lump-sum, specific and *ad valorem* subsidies are considered in turn. There are two ways to frame this examination; one is to look at the difference in expected prices across auctions with and without the subsidy, where the expectation is taken over bidders' fixed costs; the second is to look at the difference if we were to hold everything about a given auction constant including the fixed costs of the suppliers, and vary the subsidy. In the analysis that follows the second approach is taken since it is simpler and easily extended to looking at expectations over fixed costs. For ease of exposition, the notation $c^s(\theta_i) \equiv c_i^s$ and $c(\theta_i) \equiv c_i$ is adopted.

In the case of the lump sum subsidy $V_i^s = q_m(c_i^s)\, c_i^s - \mu_i(q_m(c_i^s)) + t$ and $V_i = q_m(c_i)\, c_i - \mu_i(q_m(c_i))$.

Since information rents are unchanged by the imposition of the subsidy, $V_i^s = V_i$. Hence

$$\begin{aligned} q_m(c_i)\,c_i - \mu_i(q_m(c_i)) &= q_m(c_i^s)\,c_i^s - \mu_i(q_m(c_i^s)) + t \\ &= (q_m(c_i) + \Delta q)\,c_i^s - \mu_i(q_m(c_i)) - \Delta\mu_i(\Delta q) + t \end{aligned}$$

where $\Delta\mu_i(\Delta q)$ is the change in variable costs due to the introduction of the subsidy. If $\Delta q c^s - \Delta\mu_i(\Delta q) > 0$, that is, the revenue from the additional units induced by the subsidy is greater than the cost of producing them, then $\Delta q > 0$ implies

$$q_m(c_i)\,c_i - \mu_i(q_m(c_i)) > q_m(c_i)\,c_i^s - \mu_i(q_m(c_i)) + t$$

hence, regardless of which bidder actually wins the contract,

$$c_i - c_i^s > \frac{t}{q_m(c_i)}$$

In the case of a specific subsidy the analysis proceeds, again, setting $V_i = V_i^s$

$$\begin{aligned} q_m(c_i)\,c_i - \mu_i(q_m(c_i)) &= q_m(c_i^s)\,(c_i^s + \tau) - \mu_i(q_m(c_i^s)) \\ &= q_m(c_i)\,c_i^s - \mu_i(q_m(c_i)) + \Delta q\,(c_i^s + \tau) - \Delta\mu_i(\Delta q) + q_m(c_i)\,\tau \\ &> q_m(c_i)\,c_i^s - \mu_i(q_m(c_i)) + q_m(c_i)\,\tau \quad \text{if} \quad \Delta q\,(c_i^s + \tau) - \Delta\mu_i(\Delta q) > 0 \end{aligned}$$

Hence, if the supplier were to earn a net profit on the extra units sold ($\Delta q\,(c_i^s + \tau) - \Delta\mu_i(\Delta q) > 0$),

$$c_i - c_i^s > \tau$$

The analysis of an *ad valorem* subsidy is very similar, leading to

$$c_i - c_i^s > c_i^s t \quad \text{if} \quad \Delta q c_i^s\,(1 + \tau) - \Delta\mu_i(\Delta q) > 0$$

These results are collected in Result 2

> **Result 2:** *if supplier θ^w wins the supply contract then:*
> *(a) with a specific or ad valorem subsidy if* $\Delta q\,(c_i^s + \tau) - \Delta\mu_i(\Delta q) > 0$,
> *then* $c(\theta^w) - c^s(\theta^w) > \tau$
> *(b) with an ad valorem subsidy* if $\Delta q c_i^s\,(1 + \tau) - \Delta\mu_i(\Delta q) > 0$,
> *then* $c(\theta^w) - c^s(\theta^w) > c^s(\theta^w)\,t$
> *(c) with a lump sum subsidy of size t, if* $c^s(\theta^w) - \mu > 0$, then $c(\theta^w) - c^s(\theta^w) > \frac{t}{q_m(c(\theta^w))}$

Thus, the induced price changes are greater than would be the case in a market where suppliers just set price equal to marginal cost subject to the sufficient condition that the supplier earns a net profit on the extra units sold. That is, subsidy overshifting is observed if the sufficient conditions are met. If marginal costs are constant these conditions are always met if the subsidy is specific or *ad valorem*.[12]

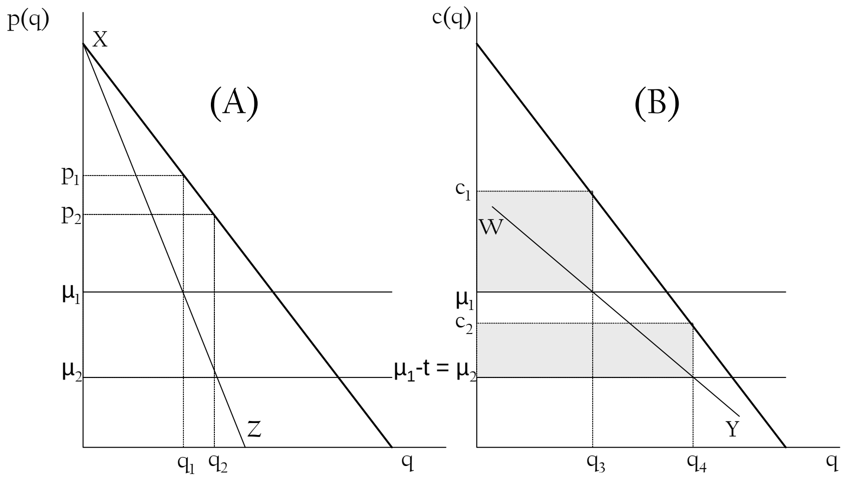

Figure 2: A subsidy to a standard monopolist (A) and a subsidy in the competitive tender environment (B).

The constant marginal cost case is useful for illustrating how the competitive tendering environment differs from other models of imperfect competition. That the overshifting occurs, without restrictions being placed on the demand curves, in this case is a result that runs counter to previous work on incidence in imperfectly competitive markets. In cournot and bertrand markets Anderson et al (2001), Dellipala and Keen (1992), Keen (1998), Stern (1987) and others have noted that overshifting is not possible unless the marginal revenue curve is flatter than the demand curve. [13] As Anderson et al point out, bertrand and cournot markets are very similar way in this regard and merely reflect the workings of a standard textbook monopoly. Figure 2(A) shows such a monopoly. Initially price is at p_1 and (constant) marginal cost is μ_1. A specific subsidy is introduced of size t which reduces the effective marginal cost to μ_2. This reduces price to p_2. Because the demand curve is steeper than the marginal revenue curve $p_1 - p_2 < t$ and no overshifting occurs.

In contrast, in panel (B) of Figure 2, the competitive tender environment is illustrated. The demand curve is the induced demand from the downstream monopolist. The upstream supplier is the winner of the tender with fixed cost θ^w. Initially the supplier is providing the input at unit price c_1 and marginal cost is μ_1. The information rent is $(c_1 - \mu_1)\, q_3 - \theta^w$ The subsidy reduces the effective marginal cost to μ_2, but this does not change the information rents. This means that,

[12] This is because when marginal costs are constant, if you are not making a positive margin on the marginal unit then you are not making a poisitive margin on any infra-marginal unit either. That is, if the sufficient condition is violated, the supplier must be making a loss, which violates an implicit participation constraint.

[13] Anderson et al (2001) provide a nice overview of the literature on this point.

since θ^w is unchanged, $(c_2 - \mu_2)\, q_4 = (c_1 - \mu_1)\, q_3$. That is, both shaded rectangles in panel (B) must have the same area. The corollary of this, illustrated in Figure 2, is that the firms bidding in a competitive tendering environment mimic a monopolist with a marginal revenue curve that is flatter than the demand curve (the line WY shows the marginal revenue curve that would generate these price and quantity outcomes). Thus, regardless of the actual shape of the demand curve, the competitive tender generates behavior that only emerges in the previous cournot and bertrand models in restrictive demand environments.

The impact on consumer prices: The effect on final consumer prices depends on the demand conditions and the size of the overshifting in the input market. For any demand curve for which marginal revenue is steeper than consumer demand, the change in consumer price in response to a marginal cost change is less than one. That is

$$\frac{\Delta p}{\Delta \tau} = \frac{\Delta p}{\Delta c}\frac{\Delta c}{\Delta \tau} \quad \text{where} \quad \frac{\Delta p}{\Delta c} < 1 \text{ and } \frac{\Delta c}{\Delta \tau} > 1$$

This may offset the overshifting occurring in the input market (i.e. $\frac{\Delta c}{\Delta \tau}$).[14] The net effect depends on the number of suppliers, the distribution of fixed costs, the size of the subsidy or tax, the degree of downstream competition (here a monopoly structure is used, but the results presented can be extended to a cournot or bertrand structure) and final demand. Notably, as the downstream market becomes more competitive, $\frac{\Delta p}{\Delta c}$ approaches 1 and the more likely it is that the overshifting effect from the input market dominates. If the procurer is the final consumer these considerations are not relevant and overshifting must occur.

3.4 The effect on profits

The analysis so far makes it clear that, when the downstream monopolist conducts a competitive tender, the suppliers retain no additional surplus. Any benefits from the subsidy accrue downstream. This raises the question of what magnitude of benefit the downstream monopolist gets. Here, the issue of the marginal deadweight loss of taxation needed to fund the subsidy is set aside and the focus is directed at the benefit that accrues to the monopolist. The monopolist's increase in profit from the imposition of the subsidy is compared to the government's expenditure.

If supplier i wins the tender, the increase in the monopolist's profit is given by

$$\Delta \Pi^m = q_m\left(c_i^s\right)\left(p\left(c_i^s\right) - c_i^s\right) - q_m\left(c_i\right)\left(p\left(c_i\right) - c_i\right) \tag{5}$$

[14] Clearly, if $\frac{\Delta p}{\Delta c} > 1$ then overshifting is magnified in the final product market. This will be the case in the environments considered by the preceding literature.

whereas the government's expenditure on the subsidy is given by $q(c_i^s)\sigma$ where $\sigma = \tau$ in the case of a specific subsidy, $\sigma = c_i^s t$ in the case of an *ad valorem* subsidy and $\sigma = \frac{t}{q(c_i^s)}$ in the case of a lump sum subsidy. Since the imposition of the subsidy does not change information rents, we can exploit the fact that $V_i = V_i^s$ and rewrite the governments subsidy expenditure as

$$q(c_i^s)\sigma = q_m(c_i)(c_i - c_i^s) - \Delta q c_i^s + \Delta\mu_i(\Delta q) \tag{6}$$

Results 3 to 5 follow:

Result 3: *If supplier i wins the tender, a sufficient condition for the increase in the monopolist's profits being greater than the expenditure on the subsidy is that $\Delta q c_i^s - \Delta\mu_i(\Delta q) \geq 0$.*

Proof: From (5) $\Delta\Pi^m > q_m(c_i)(p(c_i) - c_i^s) - q_m(c_i)(p(c_i) - c_i) = q_m(c_i)(c_i - c_i^s)$. From (6) $q_m(c_i)(c_i - c_i^s) > q(c_i^s)\sigma$ if $\Delta q c_i^s - \Delta\mu_i(\Delta q) \geq 0$. Hence $\Delta\Pi^m > q(c_i^s)\sigma$ if $\Delta q c_i^s - \Delta\mu_i(\Delta q) \geq 0$■

Result 4: *If marginal costs are constant, then for every supplier there exists a subsidy such that, should they win the tender, the increase in the monopolist's profit is greater than the expenditure on the subsidy.*

Proof: Positive ex-post profits without a subsidy implies $q_m(c_i)c_i - \mu_i(q_m(c_i)) > 0$. This implies that there exist a $\underline{c}_i < c_i$ such that $q_m(\underline{c}_i)\underline{c}_i - \mu_i(q_m(\underline{c}_i)) = 0$. If marginal costs are constant then for any $c \in (\underline{c}_i, c_i)$, $q_m(c)c - \mu_i(q_m(c)) = q_m(c)(c - \mu) > 0$ implying $\Delta q c - \Delta\mu_i(\Delta q) \geq 0$. There will always exist a sufficiently small subsidy to induce an input price $c \in (\underline{c}_i, c_i)$ ■

Combining (5) and (6), for the monopoly's profit increase to be larger than the government's expenditure on the subsidy what is required is that

$$[q_m(c_i^s)p(c_i^s) - \mu_i(q_m(c_i^s))] - [q_m(c_i)p(c_i) - \mu_i(q_m(c_i))] > 0 \tag{7}$$

From this, the economic intuition behind Results 3 and 4 becomes clear. Equation (7) examines the monopolist and winning supplier as if they were a vertically integrated firm. It compares the profit of this hypothetical integrated firm (less any subsidy payments) when it has to price at $p(c^s)$ and $p(c)$. When the profit of this integrated firm is equal under $p(c^s)$ and $p(c)$ it must be the case that the profit increase for the monopolist is equal to the expenditure of the subsidy. This can be seen by noting that in equilibrium the information rents of the suppliers never change due to the subsidy. So if the subsidy is removed (as is the case in (7)) the profit of the supplier decreases by the size of the subsidy and, to compensate, the profit of the monopolist must be increased by the same amount.

If the profit of the integrated firm is higher under $p(c_i^s)$ then the subsidy is also providing a incentive to adjust the pricing of the integrated firm so that, as a whole, it captures more surplus in the downstream market, creating value for the monopolist. When $c_i^s = \mu'(q_m(c_i^s))$ the profit of the virtual integrated firm is maximized. Hence, as long as $c_i^s - \mu'(q_m(c_i^s)) \geq 0$ the subsidy must be improving the pricing of the virtual integrated firm and so the profit increase of the monopolist must be more than the government's expenditure on the subsidy. Note that $c_i^s - \mu'(q_m(c_i^s)) \geq 0$ implies $\Delta q c_i^s - \Delta\mu_i(\Delta q) \geq 0$. Thus the condition in Result 3 is sufficient in that it may not capture a portion of the range of c^s where (7) is satisfied but $q_m(c_i^s)\, p(c_i^s) - \mu_i(q_m(c_i^s))$ is increasing in c^s.

The driving force behind Results 3 and 4 is the fact that the information rents of suppliers do not change with the subsidy. This allows the monopolist to capture all the changes to additional producer surplus induced by the subsidy. The price response to a subsidy in the competitive tender market allows the change in producer surplus to be large relative to the subsidy expenditure.

4 Equivalent subsidies paid to the downstream firm

So far only subsidies paid to the upstream suppliers have been considered in the tendering environment. Equivalent subsidies paid to the monopolist exist for the specific and *ad valorem* subsidies. It is easy to verify that a specific subsidy paid to the monopolist of τ per unit and an ad valorem cost subsidy that reduces the monopolist's input price by $\frac{tc_i}{1+t}$ are equivalent to the specific and *ad valorem* subsidies paid to the suppliers. They are equivalent in the sense of the monopolists price, the input price, output and the government's expenditure being the same.

The equivalent to the lump sum subsidy is less obvious. However, it is a straightforward exercise to show that a subsidy of $\frac{t}{q_m(g^{-1}(\bar{c}))}$ per unit where $g(x) = x + \frac{t}{q_m(x)}$ is equivalent to a lump sum subsidy paid to the upstream suppliers. Clearly, this is an unattractive design in practice, lacking any of the simplicity of a lump sum payment to suppliers and requiring complex administration and information on the part of the government.

5 Relationship to taxation

After considering downstream subsidies, attention is returned to the upstream market in the context of a supplier tax. Analogous results to Results 1 and 2 can be restated for taxes. This is done in Result 5

Result 5: *In the competitive tendering model, given* $\Delta q = q_m(c_i) - q_m(c_i^t)$, if $\Delta q c_i - \Delta\mu(\Delta q) > 0$ then

(a) with a specific or ad valorem tax $c^t(\theta^w) - c(\theta^w) > \tau$

(b) with an ad valorem tax $c^t(\theta^w) - c(\theta^w) > c^t(\theta^w)\, t$

(c) *with a lump sum tax of size* t*,* $c^t(\theta^w) - c(\theta^w) > \frac{t}{q_m(c(\theta^w))}$

The results for taxes are similar to those for subsidies. The input price changes exceed the tax paid per unit. That is, tax overshifting is observed.

In the competitive tendering environment, subject to $\Delta q c_i - \Delta\mu(\Delta q) > 0$, the monopolist's profit loss from taxation is greater than the government's tax revenue. This is an implication of the standard monopoly model, which is merely exacerbated by the effect of taxation on competitive bidding in this market. In the standard textbook model with no upstream market, a monopolist would always prefer to pay taxes in lump sum form, rather than via a distortionary tax.[15] With the upstream input market operating via a competitive tender taxes on suppliers induce the suppliers to supply fewer units at much higher prices to maintain their information rents. This raises the downstream monopolist's costs by even more than would be the case if the monopolist produced its own inputs (i.e. the standard textbook model).

6 Other Auction Formats

Despite the fact that this paper has modelled competitive tenders using the first price sealed bid auction, the qualitative results apply equally to other auction formats. The celebrated Revenue Equivalence Theorem (Myerson (1981), Riley and Samuelson (1981)) implies that, in expectation, the *ex post* value of the contract to the winning supplier is the same across auction mechanisms that set the expected profits of the supplier with the highest possible fixed cost equal to zero and have a symmetric, increasing equilibrium.[16] Importantly, while the Revenue Equivalence Result implies a form of utility equivalence for suppliers, it does not imply utility equivalence for the monopolist. The Revenue Equivalence Result means that, in expectation, the information rents of the suppliers

[15] To see this, note that in a monopoly with a tax such that $c^t - c = \tau$

$$\begin{aligned}\Delta\Pi^m &= q_m(c)(p(c) - c) - q_m(c^t)(p(c^t) - c^t) \\ &> q_m(c^t)(p(c^t) - c) - q_m(c^t)(p(c^t) - c^t) = q_m(c^t)\,\tau\end{aligned}$$

In the competitive tendering environment the only difference is that $c^t - c > \tau$.

[16] Independently and identically distributed fixed costs and risk neutrality are also required (these elements are components of the model in this paper). See Krishna (2002) for more details.

are unchanged across repetitions of the same auction. However local concavity of the monopolist's profit function would induce behavior akin to risk aversion on the part of the procurer which means that the monopolist's expected benefit from a subsidy would decreases with the variance in the bids induced by the procurement mechanism.

In addition, Results 2 to 5 need to be slightly adjusted to apply to auction formats other than the first price sealed bid auction considered above.[17] The nature of this restatement will depend on the nature of the mechanism. A second price mechanism will need to be adjusted to take into account that the price at which the contract will be fulfilled is given by the bid of the second lowest bidder. Hence, it is necessary to consider the second lowest bid. Similarly, in a third price auction, the third lowest bid will be relevant. What is required is for the proofs to consider the *ex-post* V, where this may be determined by a bidder other than the winning bidder. Despite this all the claims and proofs are substantively unchanged.

7 Conclusion

This paper has argued that the impact of a subsidy or tax imposed at some point in a vertical market structure depends crucially on the nature of the vertical market. The addition of a subsidy to the competitive tendering model explored in the paper results in price decreases that are greater than the per unit impact of the subsidy and, under plausible conditions, a profit increase to the downstream monopolist in excess of the subsidy expenditure of the government. The minimal conditions needed to obtain these results lie in stark contrast with other imperfect competition models that have been explored in the existing tax literature.

The robustness of these findings reflects the fundamentally different structure of a procurement transaction conducted via a competitive tender as compared with the more standard models of cournot or bertrand competition. In vertical markets these standard models are often not appropriate. It has been argued that appreciating this point is particularly important for drawing accurate conclusions about the impact of taxes and subsidies in manufacturing industries where complete vertical integration does not occur. The Boeing-Airbus dispute illustrates the relevance of these findings, not only to pure public finance research, but also to understanding international trade disputes, competition regulation within regions like the EU where preferential state aid is an issue and the political economy of subsidies.

Lastly, the result that the subsidy may generate a profit increase for the monopolist greater than the

[17] Some auctions, including the Dutch (or Clock) auction are strategically equivalent to the first price sealed bid auction and require no adjustment.

expenditure on the subsidy begs the question of why downstream firms do not subsidize their own suppliers. Clearly, downstream firms would prefer the government to pay the subsidy. However, in the absence of a willing government, there do appear to exist procurement mechanisms that mimic this behavior. The benefit of the subsidy is that it induces a greater output for a given (effective) price c. Further, this commitment to greater output is credible. If the procurer can commit to over-procure then they effectively can mimic the competitive impact of the subsidy. In practice we observe firms making commitments by inviting bids that are combinations of prices and quantities and announcing a scoring rule with which to evaluate these bids. When the scoring rule differs from their true profit function they can mimic the over-procurement induced by the subsidy (see Che 1993 or Asker and Cantillon 2006a & b for more on scoring rules in auctions).

References

[1] Allen, Grahame (2003), *The Industrial Development (Financial Assistance) Bill*, House of Commons Research Paper 03/15.

[2] Anderson, Simon, Andre de Palma and Brent Kreider (2001), Tax Incidence in Differentiated Product Oligopoly, *Journal of Public Economics*, 81, 173-92.

[3] Asker, John and Estelle Cantillon (2006a), Properties of Scoring Auctions, NYU and ECARES mimeo

[4] Asker, John and Estelle Cantillon (2006b), Procurement when both Price and Quality Matter, CEPR Discussion Paper 5276.

[5] Besley, Tim (1989), Commodity Taxation and Imperfect Competition: a Note on the Effects of Entry, *Journal of Public Economics*, 40, 359-367.

[6] Besley, Tim and Harvey Rosen (1998), Sales Tax and Prices: An Empirical Analysis, NBER Working Paper 6667.

[7] Congressional Budget Office (1995), *Federal Financial Support of Business*, Congressional Budget Office, Congress of the United States.

[8] Che, Yeon-Koo (1993), Design Competition through Multidimensional Auctions, *Rand Journal of Economics*, 668-680.

[9] Dellipala, Sofia and Michael Keen (1992), The Comparison between Ad Valorem and Specific Taxation under Imperfect Competition, *Journal of Public Economics*, 49, 351-367.

[10] Farnsworth, E. Allan (1990), *Farnsworth on Contracts*, Little Brown and Co. Boston.

[11] Havighurst and Berman (1932), Requirements and Output Contracts, *Illinois Law Review*, 27,1.

[12] Harris, Jeffrey (1987), The 1983 Increase in the Federal Cigarette Excise Tax, in Lawrence Summers (ed.) *Tax Policy and the Economy*, Vol. 1, MIT Press, Cambridge (1987) 87-111.

[13] Jehiel, Philippe, Benny Moldovanu and Ennio Stacchetti (1996), How (Not) to Sell Nuclear Weapons, *American Economic Review*, 86(4), 814-29.

[14] Katz, Michael and Harvey Rosen (1985), Tax Analysis in an Oligopoly Model, *Public Finance Quarterly*, 13(1), 3-19.

[15] Keen, Michael (1998), The Balance between Specific and Ad Valorem Taxation, *Fiscal Studies*, 19, 1-37.

[16] Krishna, Vijay (2002), *Auction Theory*, Academic Press, New York.

[17] Macaulay, Stewart, John Kidwell and William Whitford (2003), *Contracts: Law in Action*, 2nd Ed. Matthew Bender and Co. Newark.

[18] Mortimer, Julie (2004), Vertical Contracts in the Video Rental Industry, *mimeo*, Harvard University.

[19] Myerson, Roger (1981), Optimal Auctions, *Mathematics Op. Research, 6, 58-73.*

[20] Poterba, James (1996), Retail Price Reactions to Changes in State and Local Taxes, *National Tax Journal*, 44, 165-177.

[21] Productivity Commission (2002), *Review of Automotive Assistance*, Report No. 25, Canberra.

[22] Riley, John. and William Samuelson (1981), Optimal Auctions, *American Economic Review*, 71, 381-392.

[23] Stern, Nicholas (1987), The Effects of Taxation, Price Control and Government Contracts in Oligopoly and Monopolistic Competition, *Journal of Public Economics*, 32, 133-158.

[24] Taft, Bob 2005, Taft Launches Ambitious Strategy to Protect Ohio Automotive Industry Jobs, Press Release 11/21/2005, Office of the Governor, Ohio.

[25] Vickrey, William (1961), Counterspectulation, Auctions and Competitive Sealed Tenders, *Journal of Finance*, 16, 8-37.