

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.

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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 was that large subsidy payments (mainly in the form of tax breaks) were made to Boeing suppliers. Understanding how these subsidies 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 subsidies 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

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

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. This input market is often 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 first introduced by Vickrey (1961). The impact of a subsidy on 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) provide 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 and identically distributed across bidders.³ Each supplier's variable cost is commonly known and convex. Heterogeneity across firms' variable 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

² In the Cournot model, if demand is given by $p(q)$ what is required is $-p'(q) < p''(q)q$.

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.

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 modeling 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 discusses a series of extensions to the basic model. Finally, Section 7 concludes.

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 .

2.1. 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 reinterpretation of $D(p)$ as a residual demand curve admits a variety of other market structures. It is also assumed that the monopolist is a monopsonist, to the extent that it is 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.⁵

2.2. 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

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.

⁵ Some bids are judged on various dimensions of quality as well as price. [Che \(1993\)](#) and [Asker and Cantillon \(in press\)](#) show how standard auctions models can be easily extended to accommodate this feature.

known only to supplier i . The distribution of θ_i is given by $F(\theta_i)$, with support $\theta_i \in [\underline{\theta}, \bar{\theta}] \subset [0, V(c^*)]$ 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 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.^{7,8}

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. This contractual form is known as a requirement (or output) contract. These contracts are common in business-to-business procurement and have prompted a large legal literature.⁹

Before analysing this model, it is helpful to relate it to procurement practices used in industry. Relatively little is known, in a systematic way, about procurement practices in the private sector.¹⁰ This is due to the strictly proprietary nature of firm level procurement data. The primary source of cross-firm data on procurement practices comes from benchmarking studies done for industry. Table 1 reports selected data from a series of benchmarking surveys conducted by the Center for Advanced Purchasing Studies (CAPS) between 2002 and 2006, covering 185 large firms across 13 industry classes.¹¹

Column 3 of Table 1 reports whether any questions or responses in the survey indicated that firms in the industry used competitive bidding process to conduct procurement.¹² An 'N' of is not indicative of an industry not using competitive bidding but rather that the survey design does not invite a conclusion either way. The results suggest that competitive bidding is widespread in industrial procurement.

Column 5 of Table 1 reports the average amount spent on procurement as a percent of total revenue. This proportion varies between 17% and 57% with the median industry average being 39.47%. This is a useful number in understanding the importance of procurement. In several industries a 2% decrease in procurement costs has the same impact on profits as a 1% increase in revenue.

Column 6 of Table 1 reports the smallest % of suppliers that account for 80% of the money spent on procurement. That is, it gives a sense of the concentration of a firm's suppliers. This proportion varies between 3.5% and 15.6%. This data is not ideal; some sense of the number of contracts would be more useful. Similarly, more detail about the other end of the distribution would be helpful. This is provided by the Aerospace and Defense survey, in which it is revealed that on average 0.92% of suppliers account for 20% of procurement expenditure, and the Telecom Services survey reporting that on average 5.31% of suppliers received payments of more than 1 million dollars. Viewed in aggregate this evidence is consistent with a large proportion of inputs (by value) being sourced from relatively few suppliers. This is consistent with the modelling assumption that the terms of an individual contract may have some bearing on the productive decisions of the downstream firm.

It is also important to get some sense of how important competitive bidding processes are in the procurement process for firms. The Petroleum and Telecom Services surveys both asked firms to report the percent of contracts awarded via competitive tendering in the last 12 months. The average proportion was 50.84% and 64.2%,

⁶ This ensures all potential suppliers wish to bid in the tender with or without a subsidy. An analogous condition, for a tax, will ensure full participation with taxes.

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

⁸ Uncertainty about downstream demand can be accommodated by viewing $q_m(c)$ and $\mu(q)$ as expectations.

⁹ This literature starts with [Havighurst and Berman \(1932\)](#). Overviews are provided by [Farnsworth \(1990\)](#) and [Macaulay et al. \(2003\)](#). The cases cited therein cover a wide range of manufacturing industries including: the supply of coal to power stations, paper manufacturing, 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 \(in press\)](#) documents the use of requirement (output) contracts by movie studios.

¹⁰ More detailed information is available regarding public procurement. For an overview see [Dimitri et al. \(2006\)](#).

¹¹ The firms surveyed are listed in the online Appendix. The sample comprises a selection of firms active in a range of markets across many countries. CAPS is a joint venture between the Institute for Supply Management and Carey School of Business at Arizona State University.

¹² This may include questions about the time between soliciting bids and contract award, questions regarding eAuctions indicating firms used them, or responses to open ended questions indicating that firms used some form of competitive bidding process.

Table 1
Procurement practices across industries

Industry	No. firms surveyed	Survey evidence of		Firms' average revenue (\$Million)	Average procurement spend as % of revenue	Average % of suppliers accounting for 80% of spend	Average % of contracts awarded via competitive bidding in the last 12 months	Average % spend using eAuctions
		Competitive bidding among suppliers	Use of eAuctions					
Petroleum	17	Y	N	–	–	3.53	(50.84)	–
Diversified food and beverages	13	Y	Y	7993	56.92	–	–	–
Utilities	26	N	N	5540	26.92	((3.9))	–	–
Electronics	9	Y	Y	3214	47.76	10.87	–	–
Telecom services	8	Y	N	14,110	32.73	–	(64.2)	–
Financial services	19	Y	N	18,980	17.72	7.76	(62.75*)	–
Computer software	8	N	N	5636	31.05	15.62	–	–
Semiconductor	12	N	N	14,755	–	–	–	–
Pharmaceuticals	12	Y	Y	7689	43.17	5.97	–	(1.69)
Chemicals	15	Y	Y	9667	54.85	10.93	–	–
DOE/NNSA contractors	21	Y	Y	752	36.32	10.92	–	–
Mining	10	Y	Y	1575	46.47	–	–	(6.55)
Aerospace and defense	15	Y	Y	4843	39.47	(7.28)	–	((5.51))

Notes: All averages are across the sample of surveyed firms. *Indicates % of spend rather than % of contracts. In some instances note all firms responded to a question.

Response rates less than 80% are indicated with parentheses. Response rates less than 50% are indicated with double parentheses. No response rate below 33% is reported.

Source: CAPS (2003–2007).

respectively.¹³ The Financial Services survey 63% of procurement, by value, is done using a process where firms enter competing bids. This suggests that, at least in these industries, competitive bidding is used in the majority of procurement events and the majority of procurement by value.

Table 1 presents some evidence on the use of eAuctions, typically a descending price variant of the English auction conducted over the internet. While the surveys suggest that most firms have the capability to use eAuctions, the proportion of procurement conducted this way appears very small. This motivates the model's focus on the first-price sealed bid auction format, which better describes a competitive tendering process (see Sollish and Semanik, 2007 or Cavinato et al., 2006 for accounts of standard industry practice in this regard), rather than an English auction format that resembles eAuction procedures (this extension is discussed in Section 6).

A residual question is whether the strategically important contracts are procured using competitive bidding. Evidence of this, outside public procurement environments, is hard to obtain due to the commercial sensitivity of the information. At least in public procurement, the overwhelming trend is that high value contracts are put out to competitive tender (see Dimitri et al., 2006 for a survey). Suggestive evidence is provided of a similar trend in private sector procurement by the DOE/NNSA Contractors survey which notes that no responding firm allowed any contract worth more than \$100,000 to be offered to a supplier without a competitive bidding process, unless a satisfactory justification had been given.¹⁴ This is consistent with the default assumption being that important contracts will be put out to competitive tender.

The model focuses on the fixed cost as the source of asymmetric information between the supplier and the downstream firm. It is worth noting that the marginal costs are different across firms, albeit common knowledge. The focus on fixed cost gives considerable analytic tractability to the model. It may also be a more credible source of

¹³ 5 firms responded to this question in the Telecom Services survey and 12 in the Petroleum survey.

¹⁴ DOE/NNSA stands for Department of Energy/National Nuclear Security Administration. NNSA is a semiautonomous agency within the U.S. Department of Energy responsible for enhancing national security through the military application of nuclear science.

Table 2
Evidence of relationship specific fixed costs incurred by suppliers

Roles and/or expectations of suppliers during a new product introduction/development (1=no, 7=yes)	Mean	Min	Max	Median
1. Co-development agreements exist with our suppliers	4.85	1	7	5
2. Key suppliers integrate or co-locate their new product development activities and resources to best serve our needs	3.92	1	7	4
3. Key suppliers have R&D resources fully dedicated or otherwise committed to our new product introduction/development activities	4.31	1	7	4
4. Key suppliers apply R&D resources to support my organisation’s new product development/introduction activities	5.31	3	7	6
13 Firms responding				

Source: CAPS Diversified Food and Beverage Benchmarking Report (2007).

asymmetric information. The motivating idea is that a supplier will have to make relationship specific investments to fulfill a contract. This might include engaging in design work, reconfiguring R&D teams, relocating production or investing in specific assets. The fixed costs incurred from these activities would be hard to ascertain by an external party. An evaluation of marginal production costs may be (somewhat) more feasible from, say, a walk-through of a production facility. Table 2 reports responses from the Diversified Food and Beverage survey that speak to the importance of these fixed cost elements when procurement contracts relate to new product lines. It indicates that co-location of resources and exclusive commitment of R&D resources by suppliers are not common expectations on the part of procuring firms. Similarly, in the Electronics survey (on average) 69.25% of suppliers were expected to design components, in addition to sourcing and building them.

The impact of relaxing the monopolistic nature of the downstream firm and relaxing the assumption that $V(c^*) = \max_c q_m(c)c - \mu_i(q_m(c))$ is discussed in Section 6. This section also relates these features to industry data.

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

$$\Pi_i^s(\theta_i) = q_m(c_i)c_i - \mu_i(q_m(c_i)) - \theta_i. \tag{1}$$

First observe that $c^* = \operatorname{argmax}_c q_m(c)c - \mu_i(q_m(c_i))$ 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 one-to-one correspondence between c and $V(c)$ for $c \in [0, c^*]$.¹⁵

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:

$$\max_{V_i} (V_i - \theta_i) \Pr \left[V_i < \min_{j \neq i} V_j \right]. \tag{2}$$

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.

¹⁵ 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.

3.2. Analysis with subsidies

Three forms of subsidy (or, with a sign change, tax) are considered. The level of subsidy is denoted by 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

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

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.¹⁶ In equilibrium, however, since the distribution of fixed costs is unaffected, the information rents accruing to suppliers are unchanged from those in Eq. (2). 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 .¹⁷

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.

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

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

With the specific subsidy, V changes to $q_m(c_i)(c_i + t) - \mu_i(q_m(c_i))$. 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 Eq. (2) 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 $q_m(c)$.¹⁸

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

$$\Pi^s(\theta_i) = q_m(c_i)c_i(1 + t) - \mu_i(q_m(c_i)) - \theta_i. \tag{5}$$

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

Fig. 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 $q_m(c_i)(c_i + t) - \mu_i(q_m(c_i))$, 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 $\bar{\theta}$ as an illustration, the equilibrium bid decreases from $c(\bar{\theta})$ to $c_{SS}(\bar{\theta})$ under a specific subsidy of τ per unit and to $c_{AVS}(\bar{\theta})$ with an *ad valorem* subsidy at rate t .

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

¹⁶ Another way to view the lump sum subsidy is that it shifts the support of the distribution of fixed costs. This view, while correct, is less helpful in developing the intuition for results.

¹⁷ 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 equilibrium. 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.

¹⁸ 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.

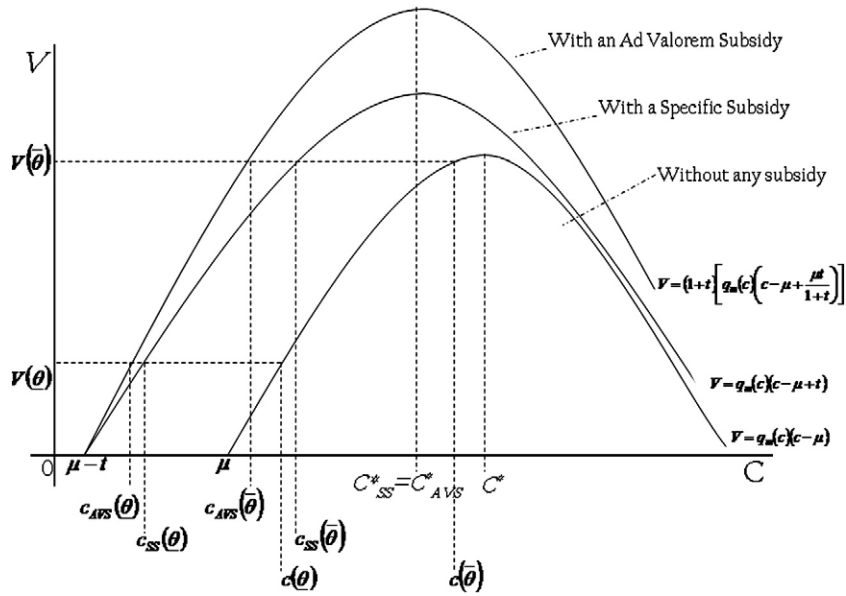


Fig. 1. The relationship between c_i and V_i , with, and without, a subsidy. [The subscript AVS indicates an *ad valorem* subsidy; the subscript SS indicates a specific subsidy; the lack of a subscript indicates the lack of a subsidy.]

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

$$q_m(c_i)c_i - \mu_i(q_m(c_i)) = q_m(c_i^s)c_i^s - \mu_i(q_m(c_i^s)) + t = (q_m(c_i) + \Delta q)c_i^s - \mu_i(q_m(c_i)) - \Delta\mu_i(\Delta q) + t$$

where $\Delta\mu_i(\Delta q)$ is the change in variable costs due to the introduction of the subsidy. If $\Delta q c_i^s - \Delta\mu_i(\Delta q) > 0$, 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 $V_i = V_i^s$

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

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

$$c_i - c_i^s > t.$$

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

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

These results are collected in Result 2.

Result 2. *If supplier θ^w wins the supply contract then:*

- (a) *with a specific subsidy if $\Delta q(c_i^s + t) - \Delta \mu_i(\Delta q) > 0$, then $c(\theta^w) - c^s(\theta^w) > t$*
- (b) *with an ad valorem subsidy if $\Delta q c_i^s (1 + t) - \Delta \mu_i(\Delta q) > 0$, then $c(\theta^w) - c^s(\theta^w) > c^s(\theta^w) t$*
- (c) *with a lump sum subsidy of size t , if $\Delta q c_i^s - \Delta \mu_i(\Delta q) > 0$, 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*.¹⁹

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.²⁰ 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. Fig. 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 Fig. 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, 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 Fig. 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.

As mentioned above, the sufficient conditions for overshifting of an *ad valorem* or specific subsidy will always be met when marginal costs are constant. This is because, when marginal costs are constant, the input price which maintains the level of information rents will always be above marginal costs (see Fig. 2). When marginal costs are increasing this may longer be the case. Fig. 3 extends the environment in Fig. 2 to the case of a specific subsidy given to suppliers with increasing marginal costs. The subsidy moves the effective marginal cost from MC_1 to MC_2 . The hatched area between MC_1 , q_1 and c_1 is the information rent before the subsidy. With the subsidy the information rent is now the shaded area determined by MC_2 , c_2 and q_2 . Note that this includes area X , which is needed to offset the larger size of the rest of the shaded region. The sufficient conditions for overshifting require that area Y be greater than X (both X and Y lie in the region between q_1 and q_2). When Y is equal to X the impact of an incremental price drop on information rents is zero, and so incremental change in c would have the same magnitude as an incremental change in a subsidy. If X is greater than Y , c_2 does not have to drop as much to maintain information rents, since the change in Y would more than offset any change in X . It follows that the flatter the marginal cost curve, the larger the suppliers' initial margins (i.e. the distance $c_1 - MC_1$ (q_1)) or the steeper the demand curve; the larger the range of subsidies that will satisfy the sufficient condition.

¹⁹ 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 positive 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.

²⁰ Anderson et al. (2001) provide a nice overview of the literature on this point.

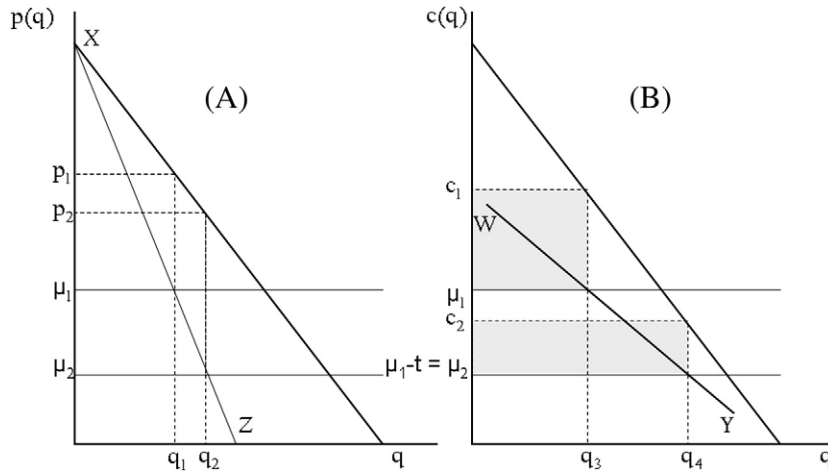


Fig. 2. A subsidy to a standard monopolist (A) and a subsidy in the competitive tender environment (B).

3.3.1. 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

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

This may offset the overshifting occurring in the input market (i.e. $\frac{\Delta c}{\Delta \tau}$).²¹ 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 the 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

$$\Delta \Pi^m = q_m(c_i^s)(p(c_i^s) - c_i^s) - q_m(c_i)(p(c_i) - c_i) \tag{6}$$

whereas the government’s expenditure on the subsidy is given by $q(c_i^s) \sigma$ where $\sigma = t$ 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

$$q(c_i^s) \sigma = q_m(c_i)(c_i - c_i^s) - \Delta q c_i^s + \Delta \mu_i(\Delta q). \tag{7}$$

²¹ 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.

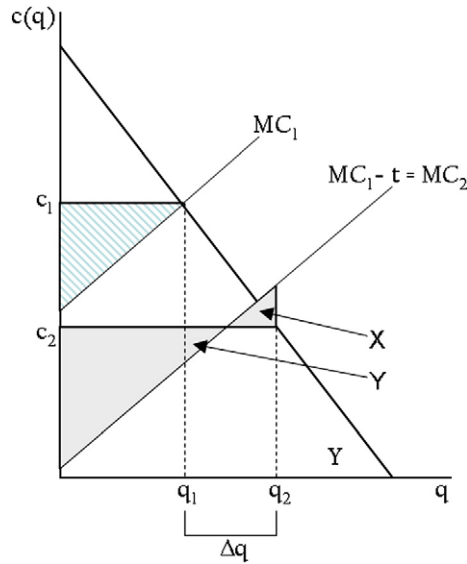


Fig. 3. A subsidy in the competitive tender environment with increasing marginal costs.

Results 3 and 4 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 $\Delta qc_i^s - \Delta\mu_i(\Delta q) \geq 0$.*

Proof. From Eq. (6) $\Delta \Pi^m > q_m(c_i)(p(c_i) - c_i^s) - q_m(c_i)(p(c_i) - c_i) = q_m(c_i)(c_i - c_i^s)$. From Eq. (7) $q_m(c_i)(c_i - c_i^s) > q(c_i^s) \sigma$ if $\Delta qc_i^s - \Delta\mu_i(\Delta q) \geq 0$. Hence $\Delta \Pi^m > q(c_i^s) \sigma$ if $\Delta qc_i^s - \Delta\mu_i(\Delta q) \geq 0$. \square

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 $c_i < c_i^s$ such that $q_m(c_i)c_i - \mu_i(q_m(c_i)) = 0$. If marginal costs are constant then for any $c \in (c_i, c_i^s)$, $q_m(c)c - \mu_i(q_m(c)) = q_m(c)(c - \mu) > 0$ implying $\Delta qc - \Delta\mu_i(\Delta q) \geq 0$. There will always exist a sufficiently small subsidy to induce an input price $c \in (c_i, c_i^s)$. \square

Combining Eqs. (6) and (7), for the monopoly's profit increase to be larger than the government's expenditure on the subsidy what is required is that

$$[q_m(c_i^s)p(c_i^s) - \mu_i(q_m(c_i^s))] - [q_m(c_i)p(c_i) - \mu_i(q_m(c_i))] > 0. \tag{8}$$

From this, the economic intuition behind Results 3 and 4 becomes clear. Eq. (8) 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 Eq. (8)) 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 an 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 $\Delta qc_i^s - \Delta\mu_i(\Delta q) \geq 0$. Thus the condition in Result 3 is sufficient in that it may not capture a portion of the range of c^s where Eq. (8) 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 $\Delta qc_i - \Delta\mu(\Delta q) > 0$ then*

- (a) *with a specific tax $c^t(\theta^w) - c(\theta^w) > t$*
- (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 $\Delta qc_i - \Delta\mu(\Delta q) > 0$, 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.²² 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).²³

6. Extensions

6.1. 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

²² To see this, note that in a monopoly with a tax such that $c^t - c = \tau$

$$\Delta \Pi^m = q_m(c)(p(c) - c) - q_m(c^t)(p(c^t) - c^t) > q_m(c^t)(p(c^t) - c) - q_m(c^t)(p(c^t) - c^t) = q_m(c^t)\tau.$$

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

²³ In this section I assume that the tax does not affect participation by suppliers. The impact of this is discussed in Section 6.3.

fixed cost equal to zero and have a symmetric, increasing equilibrium.²⁴ 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 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 decrease 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.²⁵ 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.

6.2. Downstream competition

In the model the downstream firm is a monopolist and a (limited) monopsonist. The extent of the monopsony power of the downstream firm is limited to it being able to dictate the rules of the competitive bidding process used for its own procurement. The suppliers retain some upstream market power by virtue of the asymmetric information and limited number.²⁶ Further, nothing restricts suppliers from serving several downstream firms in unrelated product markets (for example, Rolls-Royce supplies engines to manufacturers of products such as aircraft, ships and oil rigs).

More problematic for many applications is the assumption of monopoly in the product market. As noted earlier, this assumption is easily relaxed if suppliers are unable to supply components for competing products produced by different firms. In this instance, the demand curve $D(p)$ is interpreted as a residual demand curve. The full demand curve together with the solution to the downstream firm's profit maximizing problem under the appropriate product market equilibrium assumption will yield an implied demand for inputs and the analysis proceeds as above. In this setting it is the validity of Assumption 1(a) that is crucial for the analysis contained above.

Industries where either the monopoly assumption or the exclusive supplier reinterpretation is appropriate would include: natural monopolies (such as the UK water or rail industries); firms with patent protection; well functioning, stable cartels (such cartels should mimic a monopoly); and firms with a strong preference for exclusivity in their supply chain (see Whinston, 2006 for a survey of empirical work on exclusive vertical contracting). An example of a natural monopoly is Network Rail, the private company in the UK that owns and operates the national rail stock. A decrease in the cost of parts and engineering services (both of which Network Rail procures from external suppliers), via a subsidy, would increase its capacity to maintain and upgrade the rail stock, thus increasing the number of trains available to consumers. The level of these upgrades was a recurrent issue in the late 1990s (see Glaister, 2006).²⁷ An example of cartels that benefited from industry subsidization is the international shipping conferences that operated throughout the 19th and 20th century and would have enjoyed the UK's subsidization of the shipbuilding industry (see Kendall and Buckley (2001)).

Where the same supplier can provide inputs to two or more competing firms the analysis may become more complicated. If the supplier is bidding for two contracts contemporaneously Eq. (1) changes. With two competing firms downstream, the profit for supplier i from winning the contract to supply firm 1 is given by

$$\Pi_{i1}^s(\theta_{i1}, \theta_{i2}) = E(q_1(c_i, c_2) | \theta_{i2})c_i - \mu_i(E(q_1(c_i, c_2) | \theta_{i2})) - \theta_{i1}$$

²⁴ 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.

²⁵ Some auctions, including the Dutch (or Clock) auction are strategically equivalent to the first price sealed bid auction and require no adjustment.

²⁶ Note that in the absence of asymmetric information the downstream firm would not need to elicit bids. All that it would do is offer a take-it-or-leave-it contract to the lowest cost supplier at a price that extracted all the supplier's surplus. The limited number of suppliers contributes to their market power in that the downstream firm uses competition between suppliers (via bidding) to mitigate the asymmetric information problem. The fewer suppliers, the less effective is this mitigation.

²⁷ Network Rail operates under a price cap. The effect of this is to make the upper part of the monopolist's marginal revenue curve flat and to introduce a discontinuity between this region and the standard marginal revenue curve. As long as the marginal cost curve does not cross the marginal revenue curve at the point of discontinuity all the conclusions of this paper are valid. Otherwise, inequalities become equalities.

where θ_{i1} is the fixed cost to supplier i of supplying firm 1, and θ_{i2} is the fixed cost to supplier i of supplying firm 2. The complication arises from the fact that the supplier's knowledge of θ_{i2} yields information about what the equilibrium realization of demand will be, but each supplier's information is different. This creates an auction where the equilibrium bids is a function of a multidimensional signal, where one signal (θ_{i1}) enters in the manner of an independent private values model and the other (θ_{i2}) provides a common values aspect to the auction. This is an unsolved class of problem in the literature. It shares elements in common with the auctions with externalities literature started by Jehiel et al. (1996) and the multidimensional screening literature as it applied to auctions (surveyed in Asker and Cantillon, 2006). To the extent that individual suppliers act strategically across tenders, the theorems stated earlier in this paper will need to be restated, although, given the current state of the auction literature, this restatement is beyond the scope of the current paper.

It is important to stress that this issue will only arise when a supplier is bidding for two contracts contemporaneously. This means that the supplier will have information about the potential input costs of both firms that is not shared by other suppliers (leading to the reformation of Eq. (1), above). If contracts are put out to tender sequentially, and the result of each tender is realized, and known, before the next tender is announced (and the corresponding fixed cost revealed to each bidder privately), then the predictions of the model are unaffected. This is because the only private information known to a supplier is their fixed cost specific to the project at hand.

6.3. An arbitrary support for the suppliers' fixed cost

In the model it was assumed that $\theta_i \in [\theta, \bar{\theta}] \subset [0, V(c^*)]$ where $V(c^*) = \max_c q_m(c)c - \mu_f(q_m(c))$.²⁸ This is a helpful assumption in that it is a necessary condition for all potential bidders to always find winning a tender (weakly) profitable. This means that the participation constraint in the suppliers bidding problem can be ignored. If this assumption is relaxed then an economic implication is that there must be some probability that no supplier will be willing to bid for the contract. In effect there is a reserve price imposed on the auction such that V_i must be less than or equal to $V(c^*)$. Under these conditions the analysis is performed using standard results for auctions with reserve prices (see Krishna, 2002).

Conditional on at least one firm bidding for the contract, the impact of any subsidy in the presence of a reserve price will be to reduce the extent of the price reduction enjoyed by the downstream firm. This is because the subsidy will ease the constraint imposed by the reserve price and thus increase the information rents of bidders. Thus, at least for firms that would bid in the absence of a subsidy, $V_i^s > V_i$. The net welfare impact of the subsidy for the downstream firm will be determined by the cumulative effect of the price decrease and the increased probability of filling the contract.

Where a tax is so great as to diminish the chance of finding a supplier an implicit reserve price of $V(c^*) = \max_c q_m(c)(c-t) - \mu_f(q_m(c))$ or $V(c^*) = \max_c q_m(c)c(1-t) - \mu_f(q_m(c))$ is created (for specific and *ad valorem* taxes, respectively). Again, the analysis requires the same application of standard results as outlined above, with the welfare impact of the tax, for the downstream firm, determined by the cumulative effect of the price increase and the decreased probability of filling the contract.

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

²⁸ If a tax is at issue an analogous condition is assumed that ensures full participation under the tax.

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.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at [doi:10.1016/j.jpubeco.2008.01.005](https://doi.org/10.1016/j.jpubeco.2008.01.005).

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