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THE AUSTRALIAN PHARMACEUTICAL SUBSIDY GAMBIT: TRANSMUTING DEADWEIGHT LOSS AND OLIGOPOLY RENTS TO CONSUMER SURPLUS

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ABSTRACT

Australia pays less than other developed nations for her pharmaceuticals, about 45% as much as the United States. She achieves this result with an ingenious price-contingent subsidy scheme, which turns deadweight loss (due to pricing above marginal cost) into consumer surplus. Pharmaceutical companies are offered a per unit subsidy from the government for selling their product at marginal cost in the Australian market. The subsidy is calibrated to enable the companies to recover what they would otherwise receive in monopoly profits.

When two or more firms possess market power for a particular therapeutic use, the subsidy scheme creates a game -- in effect a race -- to determine who joins first and reaps most of the benefits. Properly constructed, the game transfers significant oligopoly profits to the consumer.

Australia's success -- she reaps benefits equal to 15% of its drug expenditures -- stems in part from her small size and geographic isolation. She can free ride on drug research, and can work her scheme almost without notice.

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The Australian Pharmaceutical Subsidy Gambit:

Transmuting Deadweight Loss and Oligopoly Rents to Consumer Surplus

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For at least a decade Australia has paid less for its pharmaceuticals than other developed nations do. Figure 1, based on data from the late 1970s, shows Australian prices to be substantially lower than those in 10 comparison countries.[2] The average United States price was 225% of the Australian average. The pattern was similar in 1982, when the last country-specific study was made.[3] In 1986/87, the most recent study showed, the "world" average manufacturer's price for the 80 largest-selling drugs was 82% higher than the

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[2] The figure is based on data in Ralph et al. 1979, using prices of 25 branded products and sales weights in each country. The comparisons in the figure are consistent with figures published by the Australian Pharmaceutical Manufacturers Association, which also showed prices in Belgium and Sweden to be 92% and 64% higher respectively than in Australia (Australian Pharmaceutical Manufacturers Association, 1978). This pattern of lower prices for Australia has persisted over time, suggesting that swings from purchasing power parity are not responsible for Australia's lesser prices.

[3] Industries Assistance Commission 1986, based on 1982 data on 58 drugs.

average price in Australia.[4] This pattern was remarkably consistent across drugs: about 90% of them had world average prices greater than the Australian price.

insert figure 1

Unlike most other developed countries, Australia does not regulate its drug prices directly.[5] Any drug that meets Australian safety and efficacy standards can be marketed, and those standards are administered without attention to the price of the drug.[6] Indeed, the prevailing legal view is that the Australian federal government lacks the constitutional power to regulate prices directly.

Australia's success does not depend on substantial purchases; the country represents only a small share of the world pharmaceutical market. How then does Australia manage to pay such low prices for its drugs?

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[4] From Parry and Thwaites 1988. The "world" average was based on developed countries for which data were readily available: Austria, Belgium, Canada, Finland, France, Italy, Japan, New Zealand, Spain, United Kingdom, United States, and West Germany. Although the 80 drugs were selected on the basis of Australian sales, the averages were calculated using local weights so that the "world" average reflects the relative use of those drugs overseas and the relative size of each national market. Prices are those paid to manufacturers. In these calculations, and throughout this paper, the term "drug" refers to a specific chemical compound, which may be marketed under more than one brand name.

[5] The United States, West Germany, and Switzerland also do not control pharmaceutical prices. Those nations, however, are all home to big drug manufacturers, whereas virtually all of Australia's drug purchases are from foreign-owned firms.

[6] Safety and efficacy standards are administered by a section of the federal Department of Community Services and Health that is quite distinct from the pricing section, with a very different professional environment. Perhaps more important, when decisions are taken on marketing approval, the safety regulators are usually unaware of the prices that the manufacturers will seek.

I. Australia's Price-Contingent Subsidy

Australia's secret lies in a price-contingent subsidy program. Its government pays a per-unit subsidy to the drug producer, but only if the manufacturer and the government reach agreement on price. The program is a large one in Australian terms, involving expenditures of about $A1.2 billion per year (including the retail markup), which is more than $A70 for every Australian resident. (In mid 1990 the Australian dollar, $A, was worth about 80 U.S. cents in foreign exchange markets.) For the vast majority of pensioners, the subsidy at the time of writing covered the full cost of the drug; other pensioners, the unemployed, and low-income individuals paid a partial charge of $2.50 per prescription. All the other patients were required to pay full cost up to a maximum of $A11 for each prescription, with the government covering any additional cost. Further, once a family paid for 25 prescriptions during a calendar year, its prescriptions were provided free of charge for the remainder of the year.[7]

The essence of the Australian scheme is simple. In this paper we develop a model that captures its fundamentals. In the one-producer form of the model, a monopolist is offered a per-unit subsidy if it will set price to the consumer equal to marginal cost. Sales will then increase substantially, and

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[7] In 1988/89 the average total cost of a prescription (to consumers and government) was about $A10, including the wholesale and retail components. At the time of writing, the Australian Parliament was considering a bill that would introduce a prescription charge for pensioners, increase the maximum charge for the general population, change the safety net threshold, and allow manufacturers to charge a premium if more than one brand is on the market. However none of these changes would fundamentally alter the economic impact of the price-contingent subsidy scheme.

the subsidy allows the monopolist to earn slightly more than it would receive with monopoly pricing. The deadweight loss of monopoly pricing is thus eliminated -- transmuted into consumer surplus (save a smidgen for the manufacturer). In practice, Australia's arrangement is somewhat more complex, for three reasons: it serves distributional goals beyond reducing the average price that Australians pay for drugs; the government does not have full information about costs[8]; and its specific form reflects the tug and haul of the political process.

A subsidy scheme can provide a still more impressive feat of alchemy when more than one manufacturer is competing for a market. The government can play off one oligopolist against another, inducing a race to join the subsidy scheme. If Company A has joined the scheme and is therefore charging marginal cost, profits for Company B at any price will be much lower than at the initial oligopoly equilibrium; hence the motive to join the scheme immediately. If both producers join the scheme, each is offered less than initial oligopoly profits.

Through the workings of its drug subsidy scheme, Australia saves an estimated $A200 million per year, or 15% of its expenditure on drugs. Variants of this subsidy arrangement could be employed in any market where,

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[8]Australia requires firms to submit cost data excluding R&D and advertising. The firms obviously try to tailor their accounting procedures to produce high values. Australia also undertakes analytic detective work, looking for example at costs for comparable drugs, and across markets. Finally, some information about costs emerges from the price negotiation process itself. -- See also the literature on regulating a monopoly when costs are unknown. Baron and Myerson (1982) show that incentive compatible schemes, which in effect require the monopolist to reveal his costs, are at least as good in maximizing social welfare as any non incentive compatible schemes

because of market power, price significantly exceeds marginal cost. The subsidy scheme will be particularly effective if producers are foreign, so that the government's concern for their welfare is solely strategic (e.g., it just wants them to remain in the market); their profits receive zero weight. To remove as much clutter as possible, we shall consider only the goal of increasing consumer surplus. We recognize that most subsidy schemes, including the Australian pharmaceutical subsidy arrangement, serve additional purposes. To simplify, we shall assume away any externality, distributional, or merit good arguments for consumption of the subsidized good.

The Australian government, in effect, is engaging effectively in an unusual form of two-level game. By choosing an appropriate strategy in its domestic market, it substantially improves the outcome for Australia in its dealings with foreign producers. Domestic politics have frequently been manipulated (or misrepresented) to improve outcomes in international arenas.[9] Here that strategem is extended to the microeconomic arena.

In considering consumer surplus we take research and development expenditure by the manufacturer as given. Schumpeter launched a lively argument about the economics of invention, with some (e.g., Schumpeter 1975, Arrow 1962, Mansfield et al. 1977) emphasizing that invention is a collective good, while others (e.g., Hirshleifer 1971, Loury 1979, Mortensen 1982) point to factors that encourage private firms to spend more on research and development than is socially optimal. For our present purposes, however, we need not enter that debate, since Australia comprises such a small proportion of the in-

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[9]See Putnam 1988, for a discussion of how domestic politics influence international negotiations.

ternational market for pharmaceuticals that its price has a negligible impact on the level of international research and development. In contrast to most of the literature on technical innovation, we take an unashamedly single-country perspective.

There are good theoretical reasons for the success of the Australian scheme. Its underpinnings for the case of a monopolist are reviewed in Part II. Applied to an oligopoly, Part III shows, the subsidy scheme proves to be an ingenious real-world application of game theory. Part IV returns to the Australian scheme, and Part V concludes.

II. Transmuting Deadweight Loss

We shall refer to the government as A, and the producer as B. A wishes to subsidize B's production so as to garner additional consumers' surplus for its citizenry. But of course A must consider the cost of the subsidy. For the process of subsidization to be worthwhile, the gain in consumers' surplus must exceed the cost of the subsidy. In deciding whether to undertake subsidies, therefore, government needs to look at the net consumers' surplus -- what we shall call "citizens' surplus."

The Monopolist's Decision. Consider a monopolist, B, with no fixed costs and marginal cost c, selling in a separable market offering the downward sloping demand curve DD, as shown in figure 2. The monopolist maximizes profits by setting marginal revenues equal to marginal cost at q*, with resulting price p*. The deadweight loss is the triangle ABE; profits are ABCp*.

insert figure 2

The knowledgeable government, A, looking out for all of its consumers, notices the divergence between price and marginal cost. Given prohibitions on tariffs or price controls, it may try to remedy the situation by shifting out the demand curve. If the government adds some demand at relatively low prices, shifting the demand curve to DD', the marginal revenue curve shifts to MR' once the new portion of the demand curve becomes relevant. Now marginal revenue and marginal cost are equated in two places. To choose between them, B will see which offers higher profits. In figure 2, B selects the lower-priced intersection, and sets price at p**, reaping the rectangle FGCp** as profits, an amount slightly greater than ABCp*. Consumer surplus increases by the trapezoid under the original demand curve bounded on top by p* and on bottom by p**.

The major disadvantage with the scheme just outlined is that the government ends up purchasing a considerable amount of the good. Presumably it can be resold, perhaps overseas, but not without financial loss and transactions costs. This problem can be avoided if A chooses instead to subsidize its own consumers as a mechanism for lowering price -- it is their welfare, after all, that is to be maximized.

A straightforward, per-unit subsidy is likely to be most unattractive, being both expensive and giving most of the subsidy to the producer. In figure 2, for example, the subsidy would have to raise the demand curve sufficiently to have the MR curve cut the cost curve at E. A per-unit subsidy significantly greater than p* would be required. Not only would this require a

substantial government outlay, but the producer would capture the vast preponderance of the benefits.

To resculpt the firm's marginal revenue curve, shifting it out at low prices but not at high prices, is a much more attractive option. Indeed, outward shifts at high prices are counterproductive. The simple way to accomplish the appropriate reshaping is to make the subsidy price contingent, as is shown in figure 3.

insert figure 3

The government tells the manufacturer: "charge consumers marginal cost, and I shall pay you a per-unit subsidy equal to s." The diagram is drawn so that the subsidy offers just a smidgen more profit, the cross-hatched area, than B would reap by charging the original monopoly price. The net gain to the citizens equals the increase in consumer surplus (AECp*) less the cost of the subsidy (FECG). Given that the subsidy offered to the producer is just a little more than the profit it could earn outside the subsidy scheme, the increase in citizens' surplus (the net gain in consumer surplus after paying the subsidy) will almost equal the original deadweight loss triangle. Deadweight loss has been transmuted to consumer surplus.[10]

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[10] In the pure monopoly case B might hold out for a greater subsidy, especially if A did not have full information about B's costs and the demand curve. In other words B might demand a share of the gain in consumer surplus. In the more realistic case of oligopoly discussed below, however, the firm will be fearful of its competitors being subsidized, and hence less likely to quibble.

Charging Marginal Cost. If the government seeks to maximize citizens' surplus, the optimal price to charge consumers is the marginal cost of the good, whether marginal cost is constant or increasing. (In effect, the government is paying a lump-sum amount and then purchasing at marginal cost.) This assumes that no deadweight loss is associated with raising the funds to pay the subsidy. If there is such loss, the optimal price to consumers will be somewhat above marginal cost.

With p as the price in the market, and f as the price received by the firm, we have $f = p + s$. The quantity demanded at a price is $q(p)$. With m as the maximum price anyone will pay for the good (i.e., the intersection of the demand curve with the vertical axis) we have consumer surplus equals

$$\int_{p}^{m} q(x)dx \quad . \tag{1}$$

The total cost of the subsidy is $q(p)(f-p)$. The government seeks to maximize consumer surplus less the cost of the subsidy. Computing the integral, this yields the objective

$$(2) \qquad \underset{f,p}{\text{MAX}} \quad [Q(m) - Q(p) - q(p)(f-p)] \quad ,$$

where $Q(x)$ is the integral from 0 to x of $q(x)dx$.

The participation constraint is that the firm must earn as much as it did outside the scheme, call that amount K. Let the marginal cost curve be $c(q(p))$, implying total costs of $C(q(p))$. The constraint, which we would try not to exceed, is thus

$$q(p)f - C(q(p)) = K \ .$$

(3)

Maximizing (2) subject to the constraint (3), we attach the Lagrange multiplier $\mathcal{L}$ to get as our objective

$$\underset{f,p,\mathcal{L}}{\text{MAX}} \quad Q(m) - Q(p) - q(p)(f-p) + \mathcal{L}[q(p)f - C(q(p)) - K] \ . \quad (4)$$

Setting derivatives with respect to f, p, and $\mathcal{L}$ respectively equal to zero, we get

$$- q(p) + \mathcal{L}q(p) = 0 \quad (5a)$$

$$- q(p) - q'(p)(f-p) + q(p) + \mathcal{L}(q'(p)(f - c(q(p)) = 0, \quad \text{and} \quad (5b)$$

$$q(p)f - C(q(p)) - K = 0 \ . \quad (5c)$$

From (5a), we have $\mathcal{L} = 1$. Then collecting terms in (5b) we get

$$q'(p)(f-p) = q'(p)(f - c(q(p)) \ . \quad (6)$$

Equation (6) is satisfied by setting $p = c(q(p))$, -- that is, setting the price the consumer pays equal to marginal cost. The value of f is selected so as to satisfy the constraint equation (5c).[11]

III. Transmuting Oligopoly Rents

Frequently rents are earned not by a monopolist, but by an oligopoly that is able to exercise some market power. In oligopoly situations subsidy schemes can not only transmute the deadweight loss into consumer surplus, but can also extract some of the rents, which can also be turned over to consumers. We consider a two-player oligopoly selling two differentiated products: each firm enjoys some degree of market power, but each one finds demand influenced by the other firm's price as well as its own. For simplicity, we shall consider Bertrand (price) competition, which captures our real world situation much better than Cournot (quantity) competition. We shall assume Nash equilibrium behavior, where each player takes the other's behavior as fixed, rather than more collusive but more speculative equilibrium concepts.

The Oligopolist's Decision. If we assume linear demand functions, the demand for firm i can be expressed:

$$q_i = a - bp_i + dp_j \ , \tag{7}$$

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[11] If there is a deadweight loss associated with raising a dollar of government revenue, call it d, the optimal price to the consumer will be above marginal cost. The last term in (2) is multiplied by 1+d. The value of L becomes 1+d. The critical quantity is $p - c = [-d/(1+d)][q(p)/q'(p)]$, a positive quantity since $q'(p)$ is negative. As we knew from the text, with $d = 0$, $p = c$.

where $0<b<d$ and p_j is the price charged by the other firm. If the firms have the same costs (a constant marginal cost of c) and demand, each firm earns:

$$\Pi_i = (p_i - c)(a - bp_i + dp_j) \quad . \tag{8}$$

If the firms collude to maximize their profits, then the price they both charge will be:

$$p_0 = p_i = p_j = [a + bc - dc]/[2b - 2d] \quad . \tag{9}$$

However, in the absence of collusion and with neither product subsidized, the firms could be expected to charge a price somewhere between this monopoly price and the competitive price, namely marginal cost. Though they compete, they have differentiated products. It is straightforward to derive the reaction function for each firm, assuming that it takes the other firm's price as given:

$$p_i = [a + bc + dp_j]/2b \quad ,$$

and the resulting Nash equilibrium price for both firms: (10)

$$p_e = p_i = p_j = [a + bc]/[2b - d] \quad . \tag{11}$$

To illustrate, set $a_1 = a_2 = 10$ million, $b_1 = b_2 = 1$ million and $d_1 = d_2 = 0.25$ million, with marginal cost assumed to be 2. The unsubsidized equilibrium p_1, p_2 pair has both prices set at \$6.86. The optimization process

for either firm, with its fellow duopolist's price at $6.86, is shown in figure 4.

insert figure 4

Profits are equivalent to the shaded area in figure 4. This equilibrium is also shown in the reaction function diagram (figure 5).

insert figure 5

Subsidizing One Firm. Now let the government subsidize one of the firms, say firm 1. Assume that the other firm does not react and that p_s (the price paid by consumers) is set at the marginal cost of 2. To ensure that firm 1's profit just exceeds its initial level would require a subsidy of a little over $2.43 per unit. If firm 1 were subsidized, of course, the other firm would lower its price in response, which in turn would reduce the profits of the subsidized firm.

If the government decided in advance (and was committed) to subsidize firm 1 but not firm 2, presumably the potentially subsidized firm would notice this chain of events looming and would demand a larger subsidy initially as a condition to participate in the scheme. The government must therefore offer firm 1 a subsidy that is sufficient to offer profits at the new Nash equilibrium that just exceed its Nash-equilibrium profits in the previous unsubsidized scheme.

We know the subsidized firm will be charging customers $2 for its product. The other firm, optimizing against this price of $2, will reduce its price by 61 cents to $6.25. If the first firm is to regain its presubsidy profits, it must be given a slightly larger subsidy of $2.47 for each of the units it sells.

Note that firm 1 receives roughly the same profits as it did without the subsidy scheme. Firm 2, however, is now competing with a lower-priced firm and will sell less at any price; firm 2's profits will fall. Except in pathological cases, we would expect its optimal price to be somewhat lower than it was initially. In the example here, Nash equilibrium profits for firm 2 fall by 23% to $18.1 million.

Consumers gain in two ways. First, the reduction in the consumer price of the subsidized drug produces a direct increase in consumer surplus (in our example a net gain of $35.4 million). Second, the consequent reduction in demand for the second unsubsidized drug induces a voluntary price reduction (from $6.86 to $6.25 in our example, as mentioned above). The resulting increase in consumers'surplus comes to $2.4 million in our example.[12] The cost of the subsidy is $23.6 million, the old initial profits. The net result

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[12] This figure is based on the new demand curve for the unsubsidized drug once the first drug is subsidized. In calculating the change in consumer surplus we must ignore changes in the area under the demand curve for one good brought about by a change in the price of the other, since the impact of these shifts is already captured in the change in the area under the demand curve of the other good. (For a simple explanation, see Mishan 1982.)

(after taking account of the direct cost of the subsidy) is therefore an increase in citizens' surplus of $14.2 million.[13]

The Subsidy Game. Selecting one firm to subsidize may not be optimal from the standpoint of the government or its citizens. Instead the government can place the firms in a competitive situation, where either might bolt the no-subsidy arrangement for a return that is below its current profit level.

The interesting question then is what the first firm must be offered to participate, given the possibility that the government will entice firm 2 into the subsidy scheme. In fact, as long as the firms are unable to collude, the government does not have to guarantee firm 1 the full amount that it could earn were the scheme not implemented, because there is the risk that firm 2 will participate and leave 1 out in the cold.

Various structures might be considered for the subsidy offer. Consider five options.

1. Subsidize only one firm to increase slightly its profit relative to the Nash equilibrium profit when neither firm is subsidized.

2. Offer to increase slightly the profit of any firm that bolts and takes the subsidy (again relative to the Nash equilibrium profit).

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[13]This is an uncompensated increase. Since prices are lower in the subsidized world, the value of a dollar is higher, which implies that the consumer surplus gains have been underestimated. On the other hand, no allowance is made for the excess burden of taxation to pay for the subsidy (see below).

3. Subsidize at the Nash equilibrium level any firm that bolts in the first round. Then subsidize the follower at a lower level that just exceeds the profits it could earn without a subsidy.

4. Offer to subsidize either firm at the Nash equilibrium level if it is the first to bolt, with the follower subsidized at a lower level just sufficient to induce it to opt in. If both bolt in the first round, subsidize only slightly above the level of profits each could earn without subsidy, assuming the other were subsidized.

5. Proceed as with 4, but offer the first bolter more than it would receive in the initial Nash equilibrium as a form of temptation.

Clearly option 1 would never be optimal for the government, given that citizens' surplus can always be increased by subsidizing the second product once the first is in the scheme.

Option 2 maximizes the sum of citizens' and producers' surpluses (given our initial assumption that direct price controls are not feasible). It does not reduce producers' profits and thus represents a Pareto improvement from the no-scheme situation. Such a scheme could be implemented with the full consent of the industry participants.

If the government wants only to maximize citizens' welfare, or places greater weight on citizens than producers, it will be optimal to drive a harder bargain with producers, paying a lower subsidy to a firm that does not

participate immediately, but giving it an incentive to join later. Option 3 is designed on this basis.

Option 4 creates a prisoner's dilemma situation by offering the first bolter a certain amount (epsilon) more than it would receive without the scheme. If both firms bolt simultaneously, each receives epsilon more than it would by not participating in the scheme, assuming the other does participate. Let us use the numerical values from our previous example. The critical values were 23.6, the amount each firm earned before the scheme, and 18.1, the amount a nonparticipating firm earned if the other was in the scheme (all these amounts in millions of dollars). The diagram of option 4 (Table 1) measures all payoffs relative to the no-scheme payoff of 23.6; hence the zeros in the upper left-hand box. Staying unsubsidized when the other bolts produces a loss of 5.5 (23.6 - 18.1, the latter being the amount the firm earns if only the other is subsidized). Epsilon is taken to be 0.1. Thus a 0 payoff becomes 0.1 if one bolts, and a -5.5 payment becomes -5.4. Either player has a dominant strategy to bolt at the outset.

TABLE 1

OPTION 4

	Stay	Bolt
Stay	0 0	0.1 -5.5
Bolt	-5.5 0.1	-5.4 -5.4

OPTION 5

	Stay	Bolt
Stay	0 0	5 -5.5
Bolt	-5.5 5	-5.4 -5.4

It is by no means certain that option 4 will succeed in exploiting the firms, especially if the game is expected to go on for some time. The firms

may build up a trust relationship that enables them to resist the small epsilon temptation offered by the government to induce them to defect from the stay-stay equilibrium. But the government could inhibit the development of trust by the way it structures the subsidy scheme, in particular the negotiations with manufacturers. In fact, in Australia, long lead times and secrecy in the process of selecting drugs for subsidy, combined with a tendency for doctors to prescribe the first drug introduced with new therapeutic properties, give a substantial prize to the firm that is subsidized first. In these circumstances it is difficult for the firms to trust one another, and collusion is unlikely.

Alternatively, the government might consider option 5, which raises the payoff to the first bolter, which earns considerably more than it does at the initial equilibrium. In the example of table 1, the first bolter earns 5 more. When the reward for joining up first is large enough, the temptation to do so, or the fear the other firm will, is likely to lead both firms to bolt at the outset, producing an outcome in the lower right-hand corner.

Generally we would expect options 4 or 5 -- classic prisoners' dilemma formulations -- to be the maximal exploitative strategy in a full-information situation where both players are experienced game theorists. Participation by both firms is a Nash equilibrium if neither can trust the other. The exploitation is maximal -- leaving aside the epsilon advantage to break ties -- because neither firm is earning more than it could by staying out of the scheme.

We have argued that a government seeking to maximize its citizens' surplus should capitalize on the subsidy game. Because each firm fears that the other might jump to embrace the scheme, both jump and each receives less than it did at the outset. Once one firm joins the scheme, the other will be given a small incentive to do so as well, receiving slightly more than it would outside the scheme. All deadweight loss is eliminated. Equally important to the government that does not value the welfare of the firms (or at least values it less highly than the welfare of citizens) oligopoly profits are transmuted into consumer surplus.

Since the dominant strategy in option 5 can be made exceedingly attractive, the maximum exploitation outcome is likely to be achieved.[14] With both firms following their dominant strategy, both bolt. Each firm will lose the difference between current profits and the profits of an oligopolist competing against a firm charging marginal cost.

The virtues of option 5 can be pushed further once we recognize that the critical payments are what is received in the lower right-hand box when both firms bolt. That amount is what the second player receives if the first participates in the subsidy scheme (i.e., what a player can guarantee on his own). If we subsidized sole participants, and charged zero price to consumers, the second player would be worse off. For the example given, when the first player is charging consumers 0, the second player should charge $6.00.

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[14]If the sum of the payoffs in each of the off-diagonal boxes exceeds zero, then colluding firms could do better than they would outside the scheme. They could use a coin flip to see who bolts first. Concerns about collusion would thus limit the magnitude of the payoff to the first bolter.

His profits will be 16. This suggests that it is possible to create an option 6 that, with epsilon equal to 0.1, offers[15]:

TABLE 2

OPTION 6

		Stay	Bolt
Stay		0 0	5 -7.6
Bolt		-7.6 5	-7.5 -7.5

This would seem to be the limit of reasonable schemes. This is a prisoner's dilemma situation, with a strong incentive to bolt if the other seller stays.

IV. The Scheme in Practice -- Australian Pharmaceuticals

Our analysis has been concerned with a hypothetical market, with hypothetical competitors, demand curves, and so on. We have shown how subsidies might be used to transmute deadweight loss and oligopoly profits to citizens' surplus. But economics is replete with optimal tax and subsidy schemes that will probably never be employed. Our interest in this scheme relates to its potential for application in the real world in contexts where goods are priced considerably above marginal production cost. We are en-

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[15]Of course the marginal profit for the firms in the bolt/bolt case is not really negative, or each would take its bat and ball and go home. The important thing is the profit relative to the stay/stay outcome, which we have arbitrarily set at zero.

couraged by Australia's use of a fundamentally similar arrangement in an important policy context.

The extent to which a price-contingent subsidy can increase net consumer surplus depends on own and cross price elasticities of demand, in a slightly complex fashion. Low own elasticities imply that profits were high, but deadweight loss was low. High cross elasticities boost the potential for playing firms off against one another.

Elasticity of Demand and the Computation of Gain. Despite legal restrictions on the supply of prescription drugs, demand in Australia proves to be quite sensitive to the prices that consumers pay. Johnston (1990) analyzed changes in demand (1) when the Australian subsidy arrangements were changed substantially in 1986 and (2) when patients qualify for free prescriptions under the safety net provisions. He estimated that the elasticity of demand to across-the-board changes in the general charge is at least -0.25.[16]

To give some idea of the net gain to Australian consumers, we use this estimate to derive a simple demand curve for prescription drugs, noting that at an average patient charge of about $A2.60, more than 100 million prescriptions are demanded. Assuming that in the absence of the subsidy retail prices would be 50% higher, which is very conservative given the difference shown in

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[16] Previous estimates have varied widely. Both Peltzman (1973, 1975) and Reekie (1978, 1981) have higher estimates for the U.S. market (where prices are endogenous), ranging from -0.7 to -2.83. Previous studies of the impact of exogenous price changes (e.g., in the U.S. Medicare program, the U.K. National Health Scheme, and the Australian Pharmaceutical Benefits Scheme) have been lower than the Peltzman/Reekie results. See Johnston (1990) for a description and assessment of their methodologies.

figure 1 between Australian prices and those in the United States, West Germany, and Switzerland (where prices are unregulated), we estimate that Australia gains a net $A200 million per annum in citizens' surplus through the subsidy's impact on prices.[17] The analogous figure for the United States (adjusted for population, higher drugs prices, and exchange rates) would be about $4 billion per annum. (Of course in practice the U.S. government would be unlikely to enact the producer "exploitation" aspects of the scheme, since many of the successful drug firms are based and predominantly owned in the United States.)

Cost of the Subsidy. These calculations do not take account of any deadweight loss associated with funding the subsidy, or the costs of administering it. These omissions are not important, however, for several reasons. First, a priori, it will always be optimal to pay a price-contingent subsidy, no matter how great the costs of raising the revenue or administering the subsidy.[18] A reduction in price below the level that maximizes profit in the absence of a subsidy leads to a substantial increase in output and therefore in consumer surplus, with only a small reduction in profit. This effect is simply the

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[17]By assuming a uniform patient charge and a single demand curve for prescription drugs, we have abstracted from the redistributional objectives of the subsidy scheme, which have led the Australian government to provide greater subsidies to pensioners and other low-income members of the community. We have also ignored the impact of the current subsidy on the mix of drugs demanded, on the basis that it would be possible to devise a price schedule, with higher consumer charges for more costly drugs, that would minimize distortions in the mix of drugs. To err on the conservative side, the calculation above assumes only 100 million prescriptions are consumed at $2.60, whereas the true figure is around 120 million. In-hospital expenditures, which are subject to a different set of policies, are not included.

[18]See Romano 1988. This result makes the usual assumptions about the downward slope of the demand curve and the continuity and differentiability of the demand and cost functions. It is also assumed that no fixed costs are associated with the subsidy.

converse of the common phenomenon of diminishing returns as an optimum is approached. Thus a very small subsidy, to compensate for the small reduction in profit, can generate a relatively large increase in consumer surplus.

Second, if the government plays the subsidy game we have described above, only a relatively small subsidy is required to persuade firms to participate. As soon as we move to the oligopoly case, with some degree of substitutability between the drugs, there is scope to reduce total profits and therefore the subsidy needed to entice firms into the scheme. Especially under options 4 and 6, only a small subsidy is needed when the cross price elasticity is high. A comparison of Australian prices (including the subsidy) with the unregulated prices that prevail in other coutries (figure 1) suggests that fear of competitors leads many firms to accept lower profits in Australia than they would in the absence of the subsidy scheme.

Finally, as mentioned already, the Australian subsidy scheme also achieves other social and health objectives. A goal of income redistribution, for example, is reflected in the decision to charge many consumers much less than marginal cost. Indeed it was these other objectives that prompted the establishment of the subsidy program some 40 years ago, long before its potential to lower Australia's overall drug costs was recognized. It would thus be misleading to balance the costs of the subsidy only against the economic benefits calculated above.

If all these factors were taken into account, we are confident that Australian policy makers would judge the net benefits of the subsidy to be substantially greater than $A200 million per year.

Advantages of a Price-Contingent Subsidy. Historically, Australia chose an indirect approach to pharmaceutical price controls because its federal government was barred from direct price regulation. But its experience highlights some strong reasons for using a price-contingent subsidy even if direct price control is an option.

One consideration is the credibility of the government's threat not to subsidize a drug if the firm does not agree to the offered price. In general the effectiveness of a threat depends not only on the penalty being threatened, but on the threatened party's assessment of the probability that the threat will be carried out (Schelling 1960). The Australian government can afford to take a tougher stance in price negotiations because the manufacturer knows that even if it does not accept the government's price, the drug will still be marketed in the country through the private (unsubsidized) market and through state hospitals (where pensioners and low-income individuals, who might not be able to afford to purchase in the private market, have limited access). This possibility reduces both the manufacturer's and the government's losses if agreement is not reached. It also improves the government's bargaining position. For example, supplying only 10% of the potential market provides the firm with less than 10% of its potential profits (given startup costs within Australia) but, because the demand curve is falling, patients obtain substantially more than 10% of the potential consumer surplus.[19]

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[19] Of course if these sources comprised a major share of the market, the whole price restraint mechanism would be undermined, since manufacturers would have little incentive to participate in the scheme. But in fact hospital and private market sales of unlisted drugs amount to only a small proportion of the market that can be achieved through the subsidy scheme.

By contrast, in most other developed countries drug prices are directly regulated, and marketing approval is conditional upon agreement on price. The officials of such governments are in a much weaker position in negotiating the prices of new breakthrough drugs. They must reach agreement on price before the drug can be made available to anyone in the country, and the manufacturers know it.

The effectiveness of the Australian, indirect approach to regulating prices, with marketing not dependent on pricing agreement, hinges on:

- The heterogeneity of patients. The benefits of new drugs vary considerably between patients, with a relatively small proportion of patients usually benefiting much more than others (in economic terms, a steep demand curve).[20]

- The fixed costs that manufacturers face in marketing a new drug, including the costs imposed by national regulatory requirements and higher costs associated with small production runs. The firms earn little if any profit if a new drug attracts only a small pro-

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[20] For example, patients differ substantially in the benefits they obtain from the prescription drugs with the largest dollar sales in Australia - the angiotensin-converting enzyme (ACE) inhibitors, used in the treatment of hypertension and cardiac failure. For a relatively small proportion of patients, especially those with cardiac failure or those who suffer adverse side effects from older antihypertensive drugs, these drugs offer very significant advantages. But a large number of patients with hypertension can be treated effectively with older and much cheaper drugs without adverse side effects; switching to one of the ACE inhibiters offers them little if any advantage, except perhaps the convenience of consuming a smaller number of pills per day. See for example MacCarthy 1987; Breckenridge 1988; Smith 1988.

portion of its potential market (in economic terms a falling marginal cost curve even for small quantities).

- The limitations on supply of unsubsidized drugs. Typically only those who most need the drug will obtain it through state hospitals or the private prescription market. Inhibiting factors include the inconvenience and other indirect costs of obtaining the drug through a hospital, explicit rationing by the hospital, and the high price demanded for private prescriptions (including a higher retail markup).

- The overall environment discourages collusion. Along with antitrust laws and the structure of the pharmaceutical industry, specific features of the subsidy arrangements make it most unlikely that pharmaceutical manufacturers would collude to avoid the prisoners' dilemma situation we described. (There is no evidence they have colluded in Australia.) The detailed procedures for approving new drugs for subsidy, including the discrete timing of approvals and confidentiality of applications, would undermine any cartel. A firm that chose to renege on the agreement could easily get a big jump on a competitor. Most manufacturers have just one or a few big sellers, making the situation more like a one-play game. Promises of future reciprocity are unlikely to bind good behavior.

Because the Australians whose medical needs are most pressing can obtain a drug even if its manufacturer refuses to reduce its price, the government is better able to weather any political storm that develops if a drug remains un-

subsidized.[21] Otherwise negotiators who refused to subsidize a drug would risk very concentrated criticism and lobbying. As Olson (1968) points out, such concentrated interests often prevail over diffuse interests, even though the latter's total stakes may be greater. Sales outside the subsidy arrangement thus serve as a safety valve.

A second advantage of the subsidy approach is to reduce the adverse impact that price restraint might have on other sectors of the economy. Because Australia has always depended heavily on trade with the rest of the world, on foreign investment, and on importation of technology, its governments have been keen to maintain a reputation for stability and for respect of property rights. This is not a country where an investor's property is likely to be appropriated through nationalization or more indirectly through such policy measures as price controls. The government is also eager to maintain its reputation with domestic investors, consumers, and voters.

By working through a subsidy program that is not billed as a price control mechanism and by focusing on the other objectives of the program, especially access to necessary medication by pensioners and low-income families, successive Australian governments have achieved powerful price leverage in the

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[21]For the government's negotiators to hold out and gamble on lower prices -- offering the additional benefit of setting an example for other manufacturers -- might be in the interest of other patients, but these benefits are diffused among many people, each of whom has little incentive to push the issue politically.

pharmaceutical market without causing unwarranted nervousness in other markets.[22]

V. Concluding Remarks

Like alchemy, the use of subsidies to increase economic efficiency is out of fashion. But we have demonstrated here how a price-contingent subsidy can be used to transmute deadweight loss (due to pricing above marginal cost) into consumer surplus. When more than one firm possesses market power, the subsidy can be used not only to boost efficiency, but also to generate involuntary transfers. Oligopoly profits are turned into net consumer surplus. This transmutation is particularly beneficial if the subsidizer's only concern with producer profits is strategic. We believe that the subsidy arrangements we have discussed are worthwhile in themselves. Moreover, like any selective discount, they may help to break down solidarity in cartels.

Australia has used a variant of our alchemy scheme to reap benefits equal to about 15% of its drug expenditures. In part, Australia's success may be due to the small size of its market and its geographical distance from most developed countries. It can slip by almost without notice, and the transmut-

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[22] In this context it is interesting to note that Canada eventually had to back down when it tried to control drug costs through special patent laws that required patent holders to compulsorily license others with relatively small royalties (see Eastman 1985).

It is also significant that we are not dealing with a single commodity such as a barrel of oil, but thousands of drugs that come in various combinations, forms, strengths, and pack sizes. This variety makes international pricing comparisons very difficult, and no doubt reduces the potential for Australia's low drug prices to influence price negotiations elsewhere. However, there is some evidence that its low prices somewhat reduce the rate at which new drugs reach Australia (Johnston 1990).

ing of profits to consumer surplus will have a negligible effect on drug development.

Perhaps other nations will invoke variants of this scheme when dealing with DRAM manufacturers or oil purveyors. Both chip makers and crude merchants have been known to exploit market power, yet often seem to be looking for secret ways to expand their markets. Within each group, greed (or anxiety about their rival's greed) is likely to be sufficient to motivate firms to choose the dominant action, namely to bolt to the price-contingent subsidy scheme.

Subsidies of foreign producers merit further study not just by economists, but by consuming nations.

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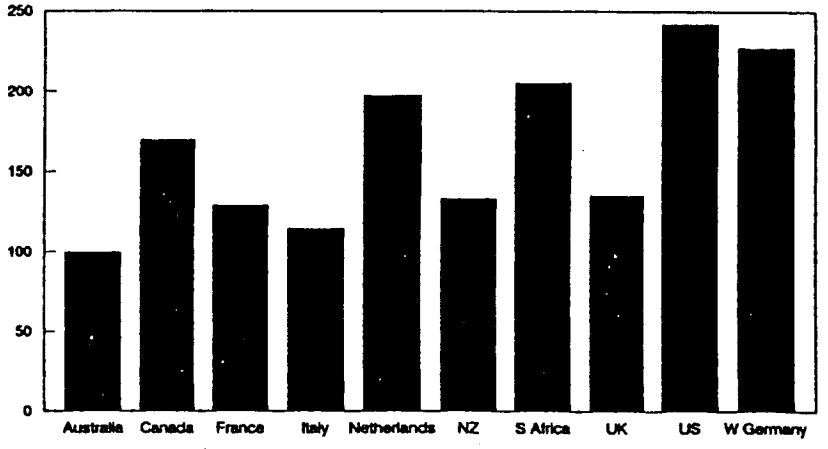
FIGURE 1

Prescription Drug Prices

Manufacturers' Prices December 1977

Australia = 100



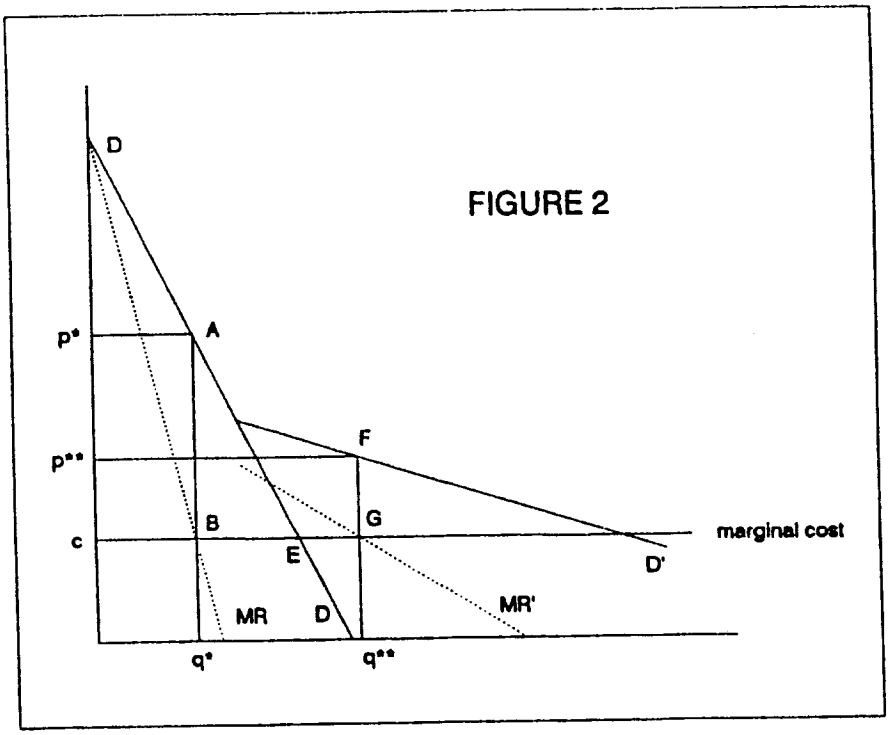


FIGURE 2
D
p*
A
p**
F
B
G
c
E
marginal cost
D'
MR
D
MR'
q*
q**

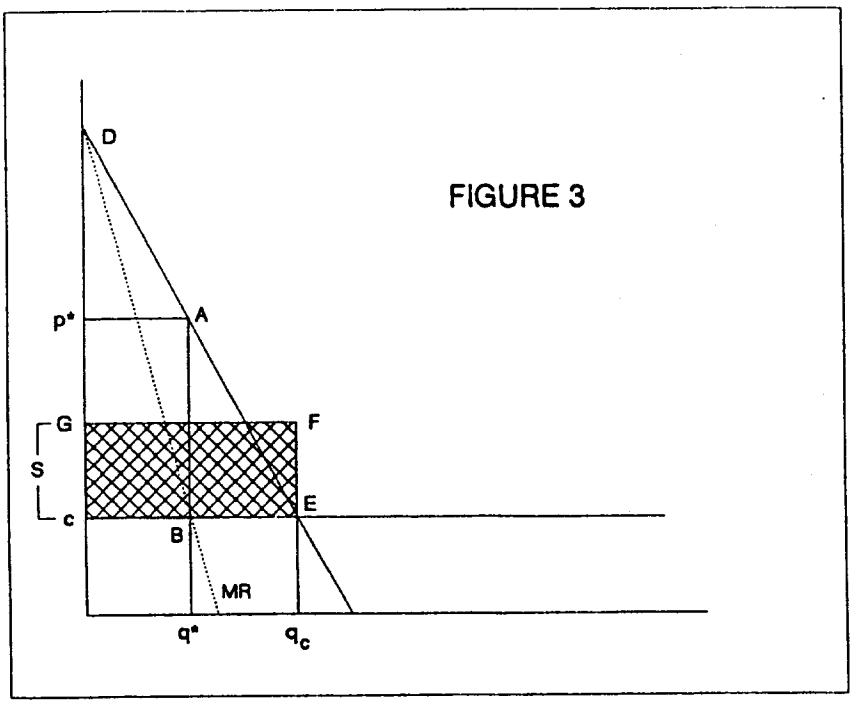


FIGURE 3

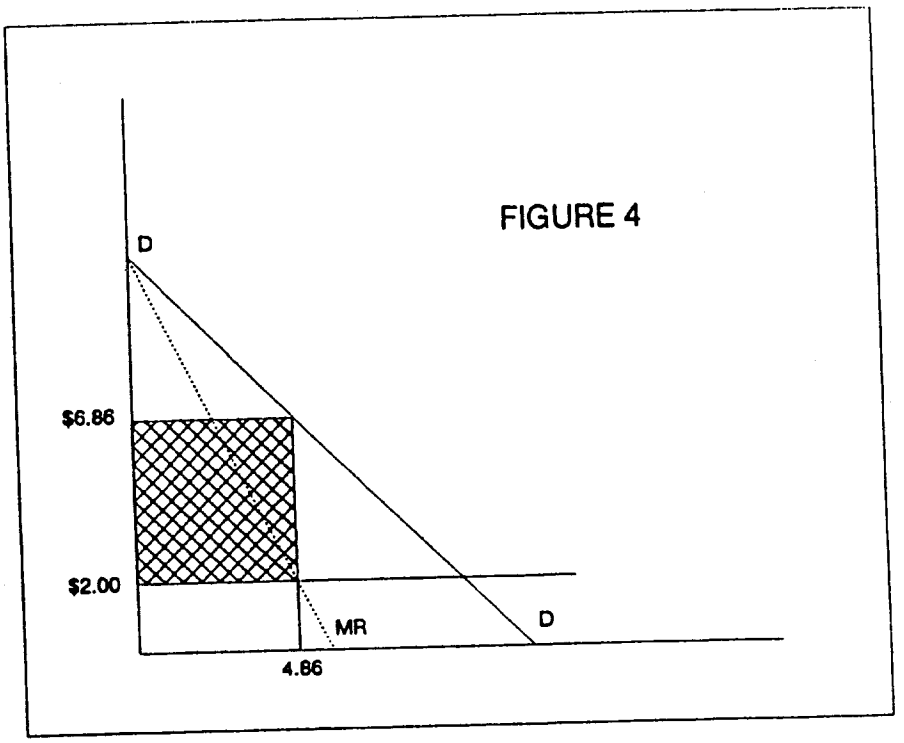


FIGURE 4
D
$6.86
$2.00
MR
D
4.86

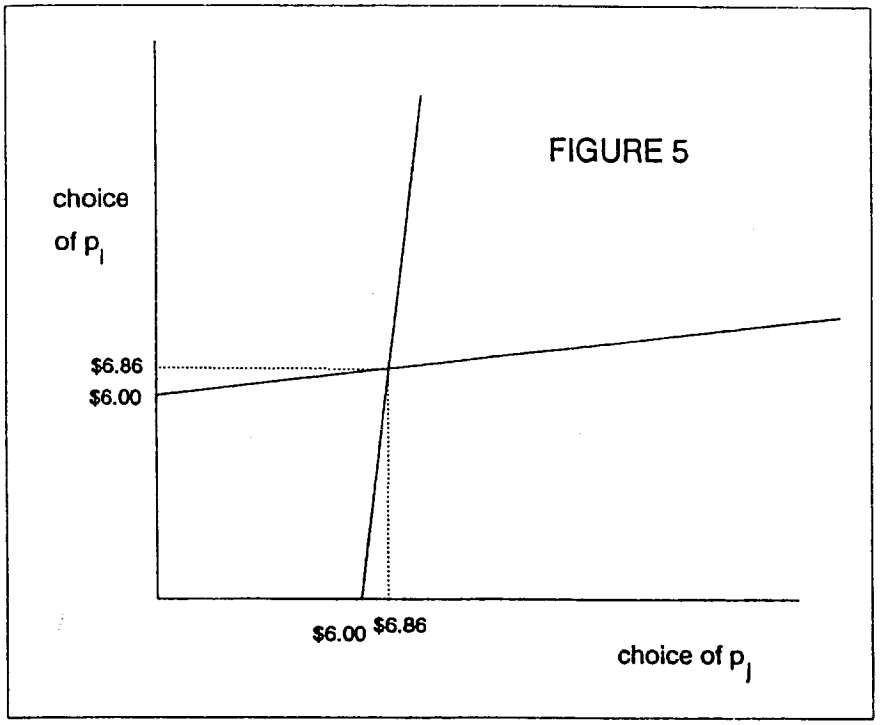


FIGURE 5
choice
of p_I
$6.86
$6.00
$6.00
$6.86
choice of p_J