

The economics of cross border trade in pharmaceuticals: theory and evidence*

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1. Introduction

The growing US consumer demand for the lower priced Canadian pharmaceutical drugs available from internet-based purveyors has raised questions about patient safety and related issues of professional liability and violation of US law. In this paper, I consider theoretical predictions on the effects of this cross-border pharmaceutical trade on the pricing decisions of multinational pharmaceutical manufacturers and the attendant effects of these pricing decisions on the profits of the multinational pharmaceutical manufacturers, its research and development activities and social welfare. I then present some empirical evidence pertaining to the potential effects of the sale of Canadian-sourced pharmaceutical drugs to US consumers. I conclude with some remarks on the likelihood that the theoretical predictions will be borne out.

2. Theory

I consider the theoretical effects within the context of the standard pricing model of a representative firm that enjoys a monopoly in the sale of a patented pharmaceutical drug in both US and Canadian markets. Most of the cross border trade is in patented drugs; the US-Canadian price differences for patented drugs are much greater than those for off-patent, genericized drugs (Palmer D'Angelo Consulting Inc, 2002). Moreover, the majority of firms selling patented drugs in Canada are multinationals and sell their products in the US as well. By considering a representative firm, this model bypasses the complexities arising from the fact that there are multiple drug firms producing multiple drugs and pricing decisions by one firm might affect the demand for another firm's drug. This simplifies the analysis without affecting the principal results.

To illustrate the concepts, I first consider the case of the pharmaceutical firm that sells in just one market. The representative firm is assumed to choose the profit maximizing price, subject to a market demand constraint and production costs. The market demand constraint implies that the higher the price chosen, the lower its sales volume will be. The demand constraint can be expressed as $q=f(p)$ where p is the price chosen and q is the sales volume, and where $\partial f(p)/\partial p < 0$; this is displayed in Figure 1. Production costs, in turn, are assumed for simplicity to be a linear function of sales volume: $cost = c \times q$ where c is the cost of producing a unit of the drug. The cost of producing each unit – i.e. the *marginal* cost – is therefore independent of total production volume and hence displayed in Figure 1 as the horizontal line marked *MC*.

Also displayed in the figure is the line marked *MR*. This denotes the revenue accruing to the firm from the sale of one more unit of the drug – i.e. the *marginal* revenue. On the face of it, the marginal revenue would appear to be the price paid – i.e. the height of the demand curve. *MR* is less than the price paid, however, for the following reason. In order to increase sales, the firm must lower the price charged to all its customers. But when it does this, all its existing customers gain from the price reduction. Thus the revenue that it takes in when it increases sales is the price it collects from its new customer minus the revenue it loses by cutting the price paid by all its existing customers. This revenue loss is clearly larger, the larger is the base of existing customers. Hence the vertical difference between the demand curve and *MR* curve increases with the firm's sales volume.

Because of the demand constraint, the firm can choose a price and accept the resulting sales volume, or implicitly choose a sales volume in which case the maximum that it can charge is set by the height of the demand curve. The desired sales volume is that level which maximizes profit. The sales volume that maximizes profit is the level at which the marginal revenue just equals marginal cost. This is indicated as sales volume Q on Figure 1. The formal derivation of the $MR = MC$ rule is provided in Appendix 1; it is

intuitively straightforward, however. At a lower sales level, it can increase profit by expanding sales (because $MR > MC$), while the converse is true if sales exceed Q .

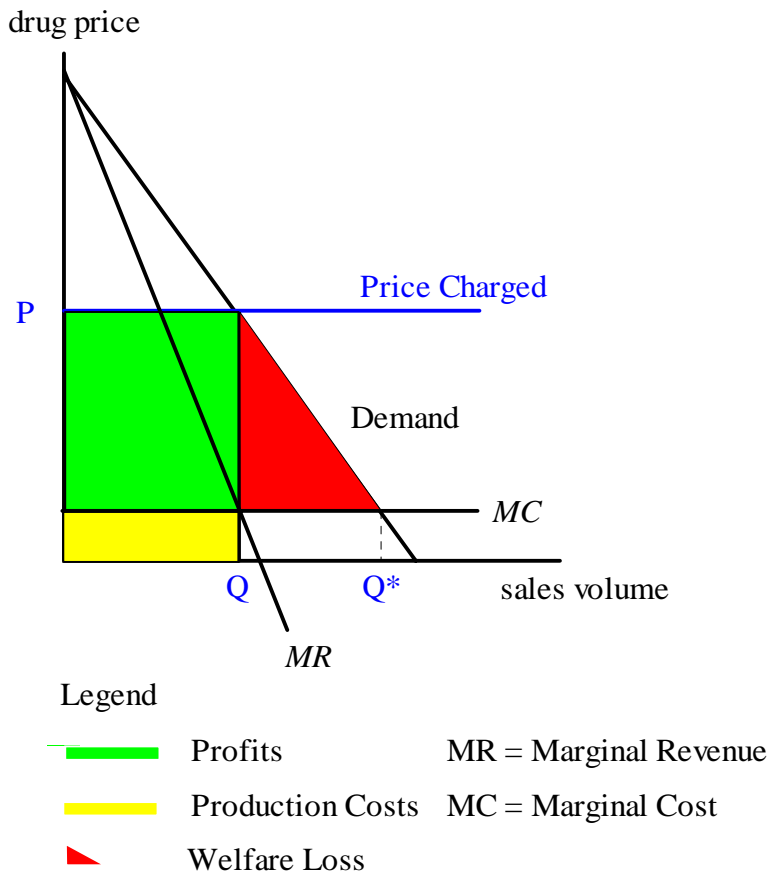
Having decided on its desired sales volume, the maximum that the firm can charge is given by the height of the demand curve. This is indicated as price P on Figure 1. The firm's profits follow from its profit maximizing price/sales volume. The firm's total revenue is simply price received for each unit of the drug sold; this is given by $P \times Q$ and is indicated in the figure as the green and yellow shaded regions. The firm's total production cost is given by $c \times Q$; this is indicated in the figure as the yellow shaded regions. Hence profit (revenue minus cost) is given by the green shaded region. It is this profit which supports the firm's research and development (R&D) and marketing efforts.

While the drug firm clearly profits from the sale of the drug, society profits as well. The *social welfare* from the consumption of drug is defined as the value generated from its consumption less the resources used up in its production. The societal value of drug consumption is conventionally measured by what consumers are willing to pay for it – i.e., the height of the demand curve. The resources used up in production of the drug are simply the cost that the firm pays – this is the height of the MC curve. The gain to society from the consumption of the drug is therefore the area below the demand curve and above MC . To maximize this area, the total sales of the drug should be at the point where the demand and MC curves intersect – this is illustrated as Q^* on Figure 1. At this point, the social value of drug consumption is just equal to the cost of its production.

Notice that with a monopoly, “too little” of the drug is consumed, relative to the level which maximizes social welfare. At Q , social welfare can be enhanced by increasing drug consumption (because the height of the demand curve $> MC$). The red shaded region in Figure 1 represents what economists call the “deadweight loss” associated

with monopoly pricing: this is the social welfare that is not realized from the under-consumption of the drug.

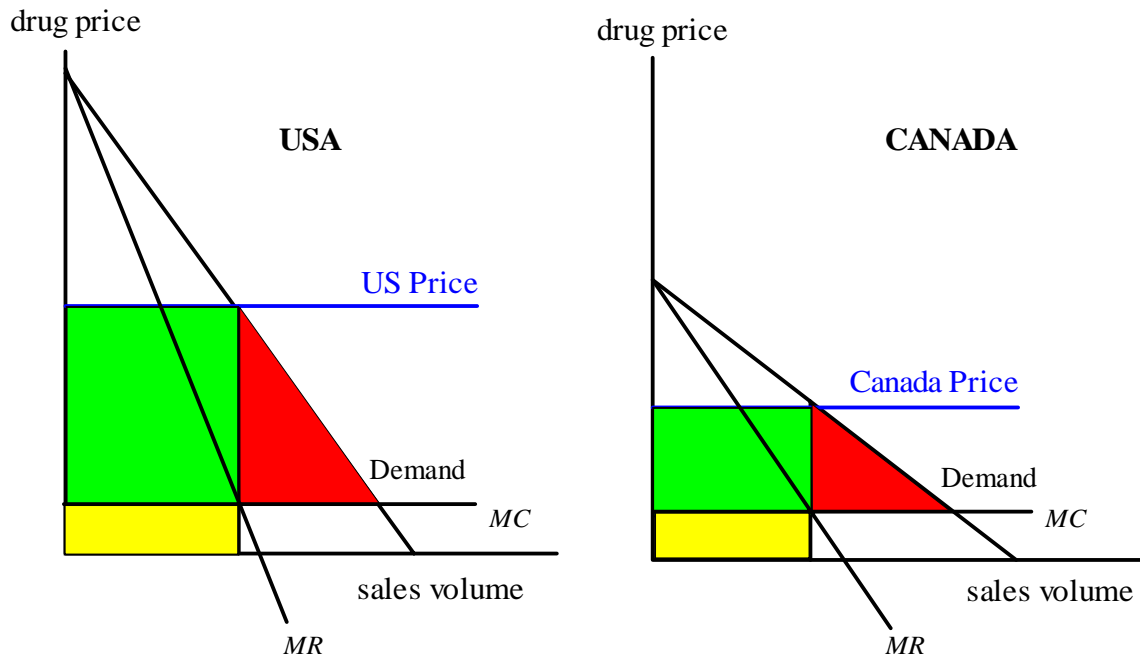
Figure 1 Drug pricing / sales chosen by a profit maximizing monopolist



Now consider the case where the firm sells in two different markets, each with different demand conditions, and is free to sell its drug at different prices. This is depicted in Figure 2 for the case of the US and Canadian markets. The US demand curve is greater at each price than the Canadian demand curve; this reflects the difference in the size of the markets and also the fact that US consumers are typically richer and are therefore willing to purchase more drugs at higher prices than are Canadians. The profit maximizing monopolist will set MC to the market specific MR and charge a higher price in the US market. The prediction that drug prices are higher in higher income markets is consistent with empirical evidence presented by Danzon and Furukawa (2004). The

practice of charging different prices to different consumers based on their demand is called *price discrimination*.¹

Figure 2 Drug prices and sales volumes in US and Canadian markets when price discrimination possible



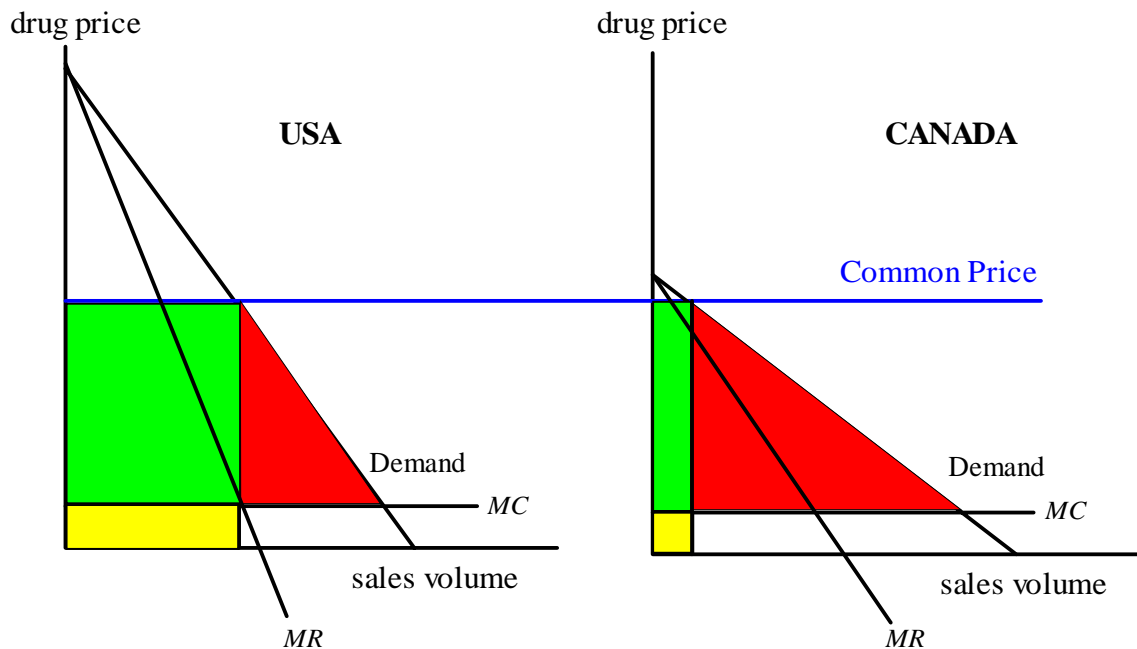
Critics of the pharmaceutical industry suggest that it is unfair that prices are higher in the US market than in other markets. The same critics are silent, however, about price discrimination practiced in other sectors, such as the airlines' practice of charging higher prices to those who are unwilling to travel over a Saturday evening, or the theatre's charging lower ticket prices to seniors. More importantly, pharmaceutical industry profits and social welfare would both be lower if price discrimination was not possible.

¹ Note that some observers suggest that the lower Canadian drug prices are a function solely of the fact that the Canadian federal government regulates the price of patented drugs sold in Canada. Grootendorst and DiMatteo (2004), however, provide data which suggests that while price regulation may have had some role, there likely have been other factors – such as income differences – which have kept Canadian prices lower than US prices.

To see this, suppose that US consumers who were previously paying the US price are able to freely purchase the drug from the Canadian market. This will substantially reduce profits in the US market. To mitigate the profit loss, the model predicts that the drug firm will increase the price charged in the Canadian market such that US consumers are indifferent between purchasing the drug domestically or importing it from Canada. Higher Canadian prices will reduce the volume of sales and profits from the Canadian market, but will restore larger US profits (Figure 3).

The pressure to equalize international prices will result in two adverse consequences. First, higher prices will also substantially increase the deadweight losses in the Canadian market. Second, the reduction in profits from the Canadian market will reduce the amount of R&D that the firm can afford to undertake in the future. Hence both consumers and producers are worse off when price discrimination is not possible.

Figure 3 Drug prices and volume of drug sold in US and Canadian markets when price discrimination not possible



3. Empirical evidence pertaining to the effect of cross border trade on pharmaceutical R&D

Multinational pharmaceutical firms appear to allocate R&D regionally partly on the basis of their perception of how accommodating a region is to its financial interests. Should the profits from the Canadian market shrink, then, there is a strong likelihood that pharmaceutical R&D expenditures in Canada will shrink as well, at least if past experience is a guide.

Two pieces of historical evidence support this position. First, the Canadian federal government extended effective pharmaceutical drug patent terms in 1987 and again in 1993, under the auspices of Bills C-22 and C-91, respectively. As is clear from Figure 4, these policies dramatically increased Canada's share of global pharmaceutical R&D. Grootendorst and DiMatteo (2004) estimate that patent term extension increased Canadian pharmaceutical expenditures by over \$4 billion (Canadian 1997 dollars) relative to what it would have been had patents not been extended.

Second, pharmaceutical R&D expenditures vary considerably between the ten Canadian provinces and it appears to be the case that provinces with relatively generous government drug plans for seniors, social assistance recipients and others, also tend to be compensated with relatively generous outlays of pharmaceutical R&D expenditure. Or equivalently, provinces with generous pharmaceutical R&D might decide not to cut drug benefits for fear of losing the R&D.

Figure 4 Canada's share of worldwide pharmaceutical research and development expenditure 1972-1997

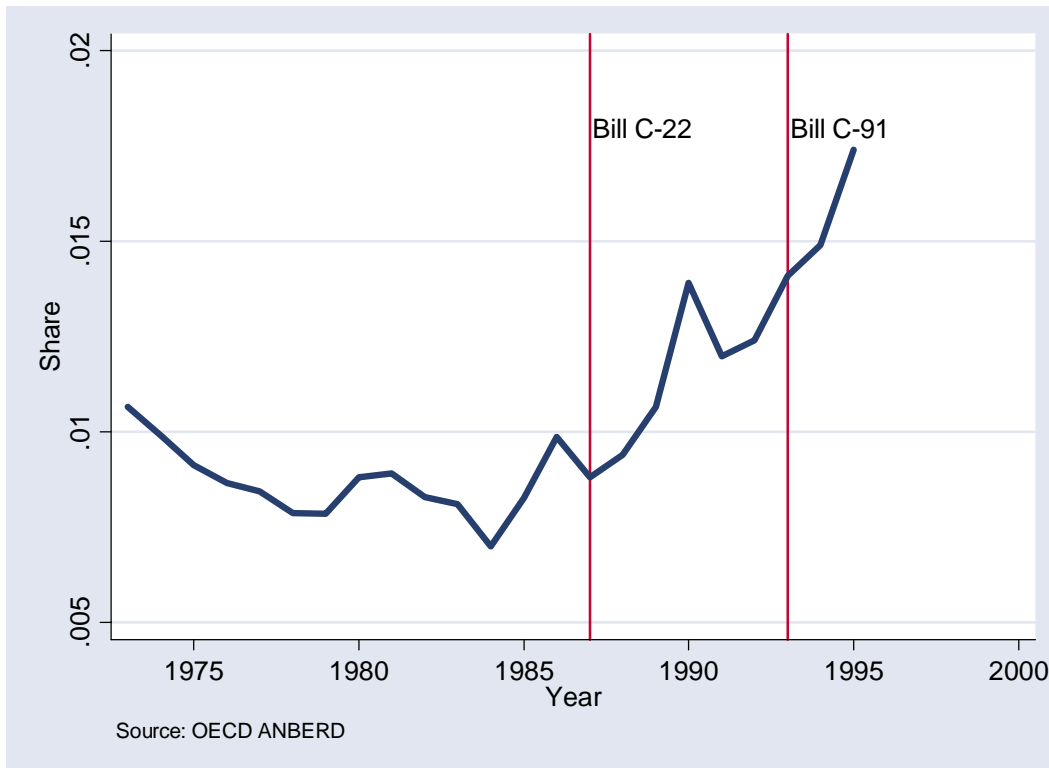
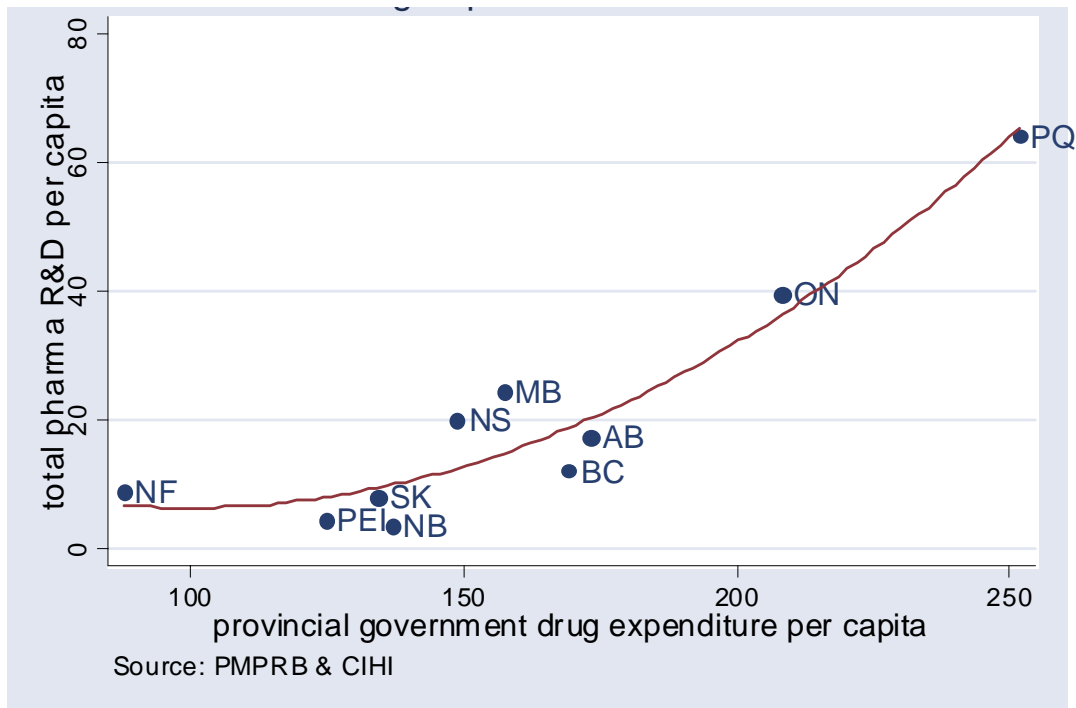


Figure 5 plots province-specific per capita outlays on provincial government prescription drug expenditures (Canadian Institute for Health Information, 2004) with province-specific per capita pharmaceutical R&D outlays by patent holding pharmaceutical firms (Patented Medicine Prices Review Board, 2003). The provinces of Quebec (PQ) and Ontario (ON) have relatively generous drug plans (Grootendorst, 2002) and drug expenditures, whereas the province of Newfoundland (NF) has a relatively non-generous drug plan and limited public drug expenditures. Drug R&D expenditures are correspondingly bigger in PQ and ON than in NF.

It is not clear if the link between drug expenditures and drug R&D is causal. For example, both could be affected by a third unknown factor. Nevertheless, the evidence is consistent with that presented in Figure 4.

Figure 5 Pharmaceutical R&D expenditure per capita and Canadian provincial government drug expenditure per capita, 2002.



4. Discussion

The standard economic model of monopoly pricing predicts that it is in the interests of both consumers and producers to facilitate price discrimination. Producers win because profits are higher and consumers win because drug consumption increases (across all markets), thereby increasing social welfare. This gain is in addition to the benefits derived from the new drugs developed with the profits accruing to producers.

Conversely, producers and consumers lose when price discrimination is not possible.

It is perhaps too early to tell whether the theoretical predictions of this model will come to fruition. Whether or not they do depends on two factors. First, the greater the volume of Canadian-sourced drugs that replace drugs that would have been purchased at US prices, the greater the profit loss, and the greater will be the upwards pressure on Canadian prices. Clearly, if drug imports are legalized in the US and HMOs and other institutions begin to purchase Canadian-sourced drugs, then the pressure on Canadian prices will be more acute. Note, however, that if the current imports in Canadian-sourced drugs are flowing primarily to US consumers who would have otherwise not consumed drugs (because they were unable or unwilling to pay US prices), then the cross border trade in pharmaceuticals actually *increases* the firm's profits. The anecdotal evidence suggests that seniors without prescription drug coverage constitute some of the US demand; whether or not they would have purchased at US prices is an open question.

Second, increases in Canadian drug prices will eventually be constrained by the Patented Medicine Prices Review Board (PMPRB), the quasi-judicial federal government agency that regulates the prices that sellers of patented drugs receive for their products. The rate of growth in drug prices is constrained to be not greater than the minimum of (1) 3 year cumulative growth in the Consumer Price Index (CPI), or (2) 1.5 times the project annual increase in CPI. According to Figure 10 of the 2002 PMPRB Annual Report (PMPRB, 2003), patented drug price inflation has been below CPI growth so that there may be some room for prices to increase without infringing PMPRB regulations. It seems likely, however, that the price inflation required to render US consumers indifferent between Canadian and US-sourced drugs will infringe PMPRB regulations. Indeed, data provided in Gross (2004) indicates that US consumers can save between 13-52% for various chronically used medications by using Canadian mail order pharmacies. Drug manufacturers might therefore use other tactics to prevent the sale of Canadian-sourced drugs to US consumers. A range of options are

available, including refusal to sell the drug in the Canadian market, or, less drastically, supplying only those pharmacies that agree to not export their drugs.

Finally, a chain is only as strong as its weakest link and it is entirely possible that even if importation of Canadian-sourced drugs into the US is curtailed, US consumers might instead seek out lower priced drugs from other countries. There will likely be considerable challenges in preserving price discrimination across different countries.

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Appendix 1 Derivation of the profit maximizing drug price in one market

The firm is assumed to choose the price/sales volume combination that maximizes profit. Choosing price implies a maximum sales volume according to the demand constraint: $q=f(p)$. Alternatively, choosing sales volume implies a maximum price that can be charge according to the inverse demand constraint $p=f^1(q)$.

Profit is defined as:

profit = revenue - cost

$$= p \times q - c \times q \quad \text{where } c \text{ is the (constant) unit cost}$$

$$= f^1(q) \times q - c \times q \quad \text{substituting } p=f^1(q)$$

at a maximum, $\partial \text{profit} / \partial q = 0$, hence the firm chooses q such that:

$$f^1(q) + \partial f^1(q) / \partial q \times q - c = 0$$

Rearranging and substituting $p=f^1(q)$ gives :

$$p + f^1'(q) \times q = c$$

This states that a profit maximum, $MR = p + f^1'(q) \times q = MC = c$, where MR is marginal revenue and MC is marginal cost.