Bargaining and International Reference Pricing in the Pharmaceutical Industry

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Abstract

The United States spends twice as much per person on pharmaceuticals as European countries, in large part because prices are higher in the US. This fact has led policymakers in the US to consider legislation for price controls. This paper assesses the effects of a hypothetical US reference pricing policy that would cap prices in US markets by those offered in Canada. We estimate a structural model of demand and supply for pharmaceuticals in the US and Canada, in which Canadian prices are set through a negotiation process between pharmaceutical companies and the Canadian government. We then simulate the impacts of the counterfactual international reference pricing rule, allowing firms to internalize the cross-country impacts of their prices both when setting prices in the US and when negotiating prices in Canada. We find that such a policy results in a slight decrease in US prices and a substantial increase in Canadian prices. The magnitude of these effects depends on the particular structure of the policy. Overall, we find modest consumer welfare gains in the US but substantial consumer welfare losses in Canada. Moreover, we find that pharmaceutical profits increase in net, suggesting that reference pricing of this form would constitute a net transfer from consumers to firms.

Keywords: Pharmaceuticals, Reference Pricing, Most Favored Nation Clause, Bargaining, Empirical Industrial Organization.

JEL Codes: L11, L13, L22, I18, I11, C51, C57

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1 Introduction

The pharmaceutical industry represents a significant part of the global economy: global pharmaceutical sales amounted to $1.1 trillion in 2016, one third of which came from the US.[1] Policymakers around the world face the challenge of balancing the long-term benefits of pharmaceutical R&D incentives against the more immediate benefits of regulating or negotiating lower drug prices (Lakdawalla (2018), Lakdawalla et al. (2009)). Innovating new drugs is expensive: the Pharmaceutical Research and Manufacturers of America (PhRMA) estimates that the average cost to develop a drug (including the cost of failure) has increased from $140 million in the 1970s to $1.2 billion in the early 2000s (both in adjusted 2000 dollars), and only 2 out of 10 drugs ever achieve sufficient revenue to cover these R&D costs.[2] DiMasi et al. (1991, 2003, 2016) document a steady evolution in the cost of innovation—figures that rise from $230 million (1987) to $500 million (2000) to $1.4 billion (2013).[3] Given the substantial cost of R&D, the profits that a pharmaceutical firm expects to make off of a drug play a large role in the firm's decision to invest in developing it. New drugs are generally protected from competition by patents in order to ensure adequate profitability, and breakthrough drug prices often greatly exceed their marginal costs of production. For example, Gilead Sciences recently priced its breakthrough hepatitis C drug, Sovaldi, at $1,000 per pill—a price that almost certainly exceeds its marginal cost.[4] Even in less extreme cases, margins can be substantial: Dubois and Lasio (2018) find margins in the range of 10-50% in the French anti-ulcer industry—in spite of French price constraints—and Linnosmaa et al. (2004) estimate Finnish drug margins to be in the range of 59-67%.

The social planner's problem is further complicated by the fact that the benefits to pharmaceutical R&D may spill over to other countries. While there exists a theoretical literature on this topic—see, for example, Helpman (1993), Grossman and Lai (2004), and **?**—there is very limited empirical work. One notable exception is Chaudhuri et al. (2006), which examines quinolone sales data to determine the effect of TRIPS global patent protection on welfare. Chaudhuri et. al. find substantial welfare losses to the Indian economy, resulting from the enforcement of foreign pharmaceutical intellectual property rights in India. Moreover, it has been shown that pharmaceutical industry profits as a whole affect R&D. Acemoglu and Linn (2004) and Dubois et al. (2015) demonstrate a positive elasticity of innovation in relation to market size. Acemoglu et al. (2006) examines whether the introduction of Medicare affected pharmaceutical innovation and shows a positive effect, as well. Filson (2012) defines a dynamic-stochastic equilibrium model

[1] QuintilesIMS Global Pharma Outlook 2016.
[2] PhRMA 2014 profile.
[3] To obtain these numbers, we adjusted the figures reported in the papers for inflation.
[4] "Sales of Sovaldi, New Gilead Hepatitis C Drug, Soar to $10.3 Billion." Feb. 3, 2015. *New York Times.*

of innovation and fits it to industry facts in order to assess counterfactuals in which either the US adopts price controls or other countries drop theirs. Dynamic models of R&D have also been employed to study other industries, such as high- and low-tech manufacturing (Peters et al., 2017).

However, as the US spends twice as much as European countries per inhabitant in pharmaceuticals—not only because of larger consumption but also because of substantially higher prices—price controls in the US are increasingly being called for in policy circles (Salter, 2015; OECD, 2017), as well as, recently, by the US administration.[5] For example, Salter (2015) discusses international reference pricing for the US as a way to reduce pharmaceutical spending, using experience in other developed countries as evidence of price reduction effects. Weiss et al. (2016) say that the US government may reduce the differential pricing that exists with respect to other markets by using an international reference pricing policy (though price controls may only be achieved following re-referencing as the US is typically a first-launched market). Such a policy was implemented on a small scale in the 1990s when the US Federal Government included a Most Favored Customer clause on pharmaceutical product prices supplied to Medicaid. Scott-Morton (1997) shows that, while firms had to provide Medicaid at their lowest price, the rule resulted in higher prices to some non-Medicaid consumers of pharmaceuticals. Most price control policies base price negotiations on external reference pricing—pricing of the same drugs in other countries. In the case of the US, and unlike Canada or most European countries, drug pricing is not currently negotiated by a centralized regulatory authority that can adopt more or less aggressive negotiating standards. The advantage of an international reference pricing policy is then that it only requires an ex post control that US prices should not be higher than prices for the same drugs in referenced countries.

In this paper, we develop a model that allows us to simulate a counterfactual international reference pricing policy in which price controls are introduced in the US, in reference to other countries' prices. Such a policy may imply changes in equilibrium prices, both in the US and the reference country. Using data from the US and Canada, our paper develops and estimates a structural model of supply and demand that allows us to assess how prices are set both in Canada and the US. In Canada, this amounts to estimating the marginal costs of products and the bargaining weights of firms that negotiate prices with regulators. In the US, it entails a Bertrand-Nash equilibrium in prices across competing firms. This gives us a setting in which we can evaluate counterfactual prices, demand, and welfare given different international pricing regimes. In particular, we simulate a policy in which the US constrains prices offered in its markets

[5] See New York Times, October 25, 2018: "Trump Proposes to Lower Drug Prices by Basing Them on Other Countries' Costs".

by the prices offered in Canada. In equilibrium, firms internalize the restrictions imposed by US reference pricing when negotiating with Canada. They also internalize the effects Canadian price setting when negotiating with the US.[6] Our approach is novel in that we study the equilibrium price setting that results due to reference pricing—both on prices in the country adopting a price control and in the reference countries. As such, we determine welfare and profit effects in the global pharmaceutical market equilibrium.[7]

We use detailed data on drug quantities and prices from IMS Health to estimate a random coefficient logit model of demand with estimated drug class-specific market sizes. We then model the price setting in a country with regulated prices (such as Canada) as the result of negotiation between pharmaceutical manufacturers and a centralized regulator under a Nash bargaining equilibrium (Horn and Wolinsky, 1988; Crawford and Yurukoglu, 2012; Grennan, 2013; Gowrisankaran et al., 2015). With these supply side assumptions, we are able to separately identify costs and bargaining parameters.[8] Since Nash bargaining involves maximizing the weighted log-sum of both parties' transaction utility, we can interpret the bargaining parameters as the degree to which countries' policymakers choose to trade off between firm profits and immediate consumer welfare.

Given our estimates of preferences, marginal costs, and bargaining parameters, we then assess counterfactual policy simulations in which pharmaceutical prices in the United States are subject to international reference pricing. Under the assumption that cost and demand parameters would not change, we simulate the counterfactual prices that result. In our counterfactual equilibrium, firms internalize the constraint that US prices must be lower than prices in Canada, while simultaneously price negotiations in Canada internalize the impact of the their result on price setting in the US.

Our results show that such a policy results in a slight decrease in US prices and a substantial increase in Canadian prices. The magnitude of these effects depends on the particular structure of the policy. The effect appears to be asymmetric because of the size differences in pharmaceutical markets across countries, the bargaining parameter value in Canada, firms' marginal costs and the shape of demand in each country. Overall, we find modest consumer welfare gains in the US, but substantial consumer welfare losses in Canada. Moreover, we find that pharmaceutical profits increase in net, suggesting that reference pricing of this form would constitute a net transfer

[6] In counterfactuals in which the US imposes reference pricing, we assume that price setting is set via negotiations with regulators as is the case in other countries that use reference pricing schemes.

[7] Danzon and Chao (2000a) and Danzon et al. (2005) also study the equilibrium effects of international reference pricing, examining its effects on delayed entries of new drugs in reference countries.

[8] Dubois and Lasio (2018) instead chooses to model price setting in France as setting price ceilings that constrain firms.

from consumers to firms. Our analysis sheds new light on the price effects of reference pricing and shows the costs and benefits of a most favored nation policy in the US.

The effects demonstrated by our analysis are in addition to the negative impacts that previous work has shown reference pricing to have on entry in referenced countries (Danzon and Chao (2000b), Danzon et al. (2005), Maini and Pammoli (2019)). Our analysis holds entry/exit fixed and so it does not internalize such an effect. Moreover, while our analysis shows the effects on consumer welfare and manufacturing profits, it likely underestimates the long-term welfare impact as revealed preferences from current consumers and regulators' behavior probably do not fully internalize the trade-off between current and future generations.

Our paper is structured as follows. Section 2 presents the data used for Canada and the US. Section 3 presents the demand model that we use for each market and country, as well as its identification method. Section 4 introduces the supply side models, both for regulated and unregulated pharmaceutical markets, that we estimate in order to identify structural supply side parameters. It then presents the supply side identification method and estimation results. Finally, section 5 develops a counterfactual model of international reference pricing. Section 6 concludes.

2 Data and Descriptive Statistics

We use data from IMS Health on revenues and quantities of drugs at the quarter level from 2002 to 2013. Our data spans the United States and Canada—the main markets in our study—as well as France, Germany, the UK, Italy, and Spain, which we use to construct instrumental variables for our identification strategy. Observations in our data are at the product-dosage level by country and quarter, and by hospital, retail or other channel of use. The data also includes product characteristics and the manufacturer name. We aggregate drugs across multiple dosage forms and administering methods (e.g., tablets and injections) using "standard units", the minimal dosage of a given drug. We use the international drug name in the data to match drug names across countries. We aggregate sales to the molecule-corporation-market level and aggregate generics for each molecule. We focus on prescription drugs and do not study the OTC market. We leave the question of the consequences of having country-specific definitions of OTC versus prescription drugs for future research. We compute quarterly drug prices as the ratio of total revenue and total quantity in standard units.

Our data details each drug's Anatomical Therapeutic Chemical (ATC) Class. In the ATC system, all drugs are classified into groups at five different (nested) levels. Our data contains the

fifth ATC classification level (ATC-5) for each drug. For example, the classification of metformin (brand names: Glumetza, Fortamet, Glucophage, Riomet) is at the 1st Level (Anatomical Main Group): (A) Alimentary tract and metabolism; at the 2nd Level (Therapeutic Subgroup): (A10) Drugs used in diabetes; at the 3rd Level (Pharmacological Subgroup): (A10B) Blood glucose lowering drugs; at the 4th Level (Chemical Subgroup): (A10BA) Biguanides; and at the 5th Level (Chemical Substance): (A10BA02) Metformin.

We define markets at the ATC-4 class level. We restrict our focus to the 31 ATC-4 classes for which we have at least one on-patent molecule both in Canada and in the US.[9] These 31 ATC-4 classes are drawn from a set of 25 ATC-3 classes that covers 93% of total hospital drug expenses in the US and 72% in Canada. We describe the treatment types by ATC-3 classes covered in our analysis in Table 2.1 below.

Table 2.1: *ATC-3 Description and Summary Statistics*

ATC 3 Class	Treatment Type
A2B	Antiulcerants
A10C	Insulins and analogs for injection, immediate acting
B1B	Heparins
C2A	Antihyper- Tensives
C7A	Beta-Blocking Agents
C8A	Calcium Antagonists
C9A	Ace Inhibitors
C10A	Cholesterol- And Triglyceride-Regulating Preparations
L1A	Alkylating Agents
ATC-2 L1	Antineoplastic Alkylating Agents
L1B	Antimetabolites
L1C	Plant-Based Antineoplastics
L1D	Antineoplastic Antibiotics
L1X	Other Antineoplastics
L2B	Cytostatic Hormone Antagonists
L4X	Other Immunosuppressants
M1A	Nonsteroidal Antirheumatics
M5B	Bone Calcium Regulators
N1A	General Anesthetics
N1B	Local Anesthetics
N2A	Narcotics
N2B	Nonnarcotics And Antipyretics
N3A	Antiepileptics
N5A	Antipsychotics
N6A	Antidepressants And Mood Stabilizers

[9] That is, we exclude ATC-4 classes in which Canada does not have any on-patent molecules, while the US does. This typically happens because of the delayed entry of new molecules in Canada.

Table 2.2 shows descriptive statistics on the number of molecules by on-patent/off-patent branded and generic status within each ATC-4 class, in the US and in Canada. In addition, Table 2.2 displays the share of expenditures of US and Canadian hospital sector pharmaceutical spending that each ATC-4 class represents. There is variation across ATC-4 classes in the proportion of drugs with enforceable patents. ATC-4 classes in which most molecules' patents are expired typically have most drugs available in generic—and so, inexpensive—form. In these cases, lowering prices in the US is of less interest.

There is also variation in the share of expenditures that different ATC-4 classes represent between Canada and the US. In Canada, anti-cancer drugs (L1 class) represent a relatively larger share of total expenses (around 35%) than the 20% that they represent in the US. By contrast, the share of US spending on anti-thrombotic agents is much larger (16.8%) than in Canada (7.9%). The distribution of relative expenses across drug classes is thus different between the two countries, even though the US spends more in absolute value in every ATC-4 class and pays higher prices on almost all drugs, as shown in Table 7.1 in Appendix 7.1. Although the composition of drugs sold within each class in each country is different, the ATC-4 level average price is much higher in the US in almost every class and quarter. In fact, there is likely to be a negative correlation between prices and quantities within each class that makes the average price by ATC-4 class potentially less different across countries, in addition to the fact that some expensive drugs are sometimes not even sold in Canada.

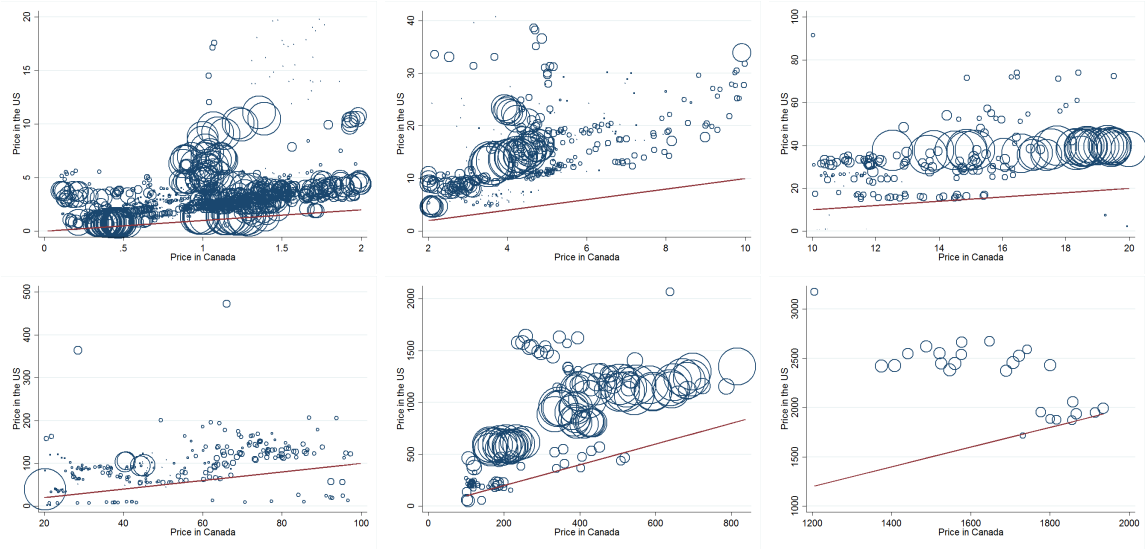
For drugs that are sold in both the US and Canada, it is interesting to verify that prices are indeed higher in the US than in Canada, as this is one of the motivation for policymakers to propose price control policies. Figure 2.1 shows a scatter plot of prices in the US against prices in Canada for the on-patent drugs present in both countries and across different ranges of prices in $US per standard unit. As shown in the figure, most drugs are more expensive in the US than in Canada by a large amount that is increasing in absolute value with the price of the drug in Canada. The ratio of prices between the US and Canada slightly decreases, however, so that the most expensive drugs are priced similarly across the two countries.

Table 2.2: *Number of molecules and expenditure shares by ATC-4*

		Canada				US			
		Number				Number			
ATC4	Label	On Patent	Branded Off Patent	Generics	Expenditure Share (%)	On Patent	Branded Off Patent	Generics	Expenditure Share (%)
A10C1	H INSUL+ANG FAST ACT	3	0	0	0.66	3	0	0	1.16
A2B2	ACID PUMP INHIBITORS	4	1	1	3.36	6	1	1	4.12
B1B2	FRACTIONATED HEPARINS	4	0	0	7.98	3	0	0	16.81
C10A1	STATINS (HMG-COA RED	3	0	3	3.19	3	2	3	2.39
C2A2	ANTIHYPER.PL MAINLY PERI	1	2	4	0.32	2	1	4	0.51
C7A0	B-BLOCKING AGENTS,PLAIN	2	3	10	1.22	2	10	12	2.18
C8A0	CALCIUM ANTAGONIST PLAIN	2	3	3	1.90	3	5	5	2.50
C9A0	ACE INHIBITORS PLAIN	5	5	6	1.55	2	6	9	0.58
C9C0	ANGIOTEN-II ANTAG, PLAIN	5	0	0	1.10	7	0	0	0.96
L1A0	ALKYLATING AGENTS	5	2	3	1.75	9	4	5	2.06
L1B0	ANTIMETABOLITES	4	4	5	7.90	7	2	9	6.84
L1C0	VINCA ALKALOIDS	2	4	6	10.84	4	2	5	4.79
L1D0	ANTINEOPLAS. ANTIBIOTICS	3	3	5	4.07	4	4	5	2.17
L1X4	A-NEO PROTEIN KINASE INH	9	0	0	9.31	11	0	0	0.96
L1X9	ALL OTH. ANTINEOPLASTICS	2	1	2	2.67	7	0	3	1.26
L2B2	CYTO ANTI-ANDROGENS	1	2	3	0.91	2	0	1	0.11
L2B3	CYTOSTAT AROMATASE INHIB	3	0	0	1.87	4	0	0	0.14
L4X0	OTHER IMMUNOSUPPRESSANTS	5	1	2	3.72	8	2	3	1.75
M1A1	ANTIRHEUMATICS NON-S PLN	2	2	5	0.38	3	5	14	0.40
M5B3	BISPHOSPH OSTEOPOROSIS	2	2	2	0.59	3	0	0	0.47
N1A1	INHAL GEN ANAESTHETICS	1	1	2	3.68	1	2	2	8.26
N1A2	INJECT GEN ANAESTHETICS	3	3	5	2.27	2	5	8	6.36
N1B1	ANAESTH LOCAL MEDIC INJ	2	3	3	0.98	2	2	5	1.12
N1B3	ANAESTH LOCAL TOPICAL	1	1	1	1.73	3	2	3	1.16
N2A0	NARCOTIC ANALGESICS	2	6	9	5.19	2	6	16	7.06
N2B0	NON-NARCOTIC ANALGESICS	3	4	6	0.56	2	5	16	0.93
N3A0	ANTI-EPILEPTICS	3	7	11	2.71	7	7	13	6.67
N5A1	ATYPICAL ANTIPSYCHOTICS	3	4	4	14.81	9	1	2	13.16
N5A9	CONVNTL ANTIPSYCHOTICS	4	1	9	1.13	2	2	8	0.71
N6A4	SSRI ANTIDEPRESSANTS	1	4	5	1.11	2	3	4	1.70
N6A9	ANTIDEPRESSANTS ALL OTH	2	3	13	0.54	5	8	12	0.71

Note: Average number of molecules (rounded to closest integer) and expenditure shares within country over 2002-2013, by ATC-4 classes. Some ATC-4 abbreviated labels have been revised and are not used anymore. See details of classification in European Pharmaceutical Market Research Association (2018).

Figure 2.1: *Comparisons of Prices of On-Patent Drugs present in both the US and Canada*



Note: Graphs for different ranges of the price in Canada (because of large variation of prices of drugs in $US per standard unit). Within each graph, the circle size is proportional to the sales value of this drug in the US.

3 Demand Model

Pharmaceutical bargaining depends, in large part, on consumers' substitution between competing drugs at different price levels. Regulators consider how each proposed price change will impact total consumption (and subsequently welfare), while manufacturers consider how it will impact profits. In order to take this into account, we estimate a flexible model of aggregate consumer demand for drugs within each market. We use a standard random utility discrete choice model in which consumers' utility is a function of prices and available drug characteristics. We cannot observe data on the behavior of insurers, healthcare providers and other intermediaries between patients and drug manufacturers, and so we abstract away from modeling them and do not disentangle their role in aggregate revealed preferences. We focus on purchases made in the hospital sector. Hospitals typically fully internalize the prices of drugs that they purchase on behalf of patients, who compensate the hospitals at a per-diem basis. By contrast, consumers making purchases in the retail sector often defer to doctors' prescriptions and pay co-pays that do not fully reflect the differences in prices. As such, consumers in the retail sector may not fully internalize differences in drugs, and so the revealed preference expressed in their observed purchase decisions is more difficult to interpret for the purpose of welfare analysis. Thus, while we do observe retail sales data, we focus on the hospital sector for our analysis.

3.1 Demand Specification

We model the drug choice problem of a representative consumer as follows. A drug market is defined by a level 4 Anatomical Therapeutic Chemical (ATC-4) class, a country (e.g. Canada and the US), and a fiscal quarter. We denote fiscal quarters by t, countries by c and ATC-4 classes by m. Consumer preferences for each drug in a market are defined according to a random coefficient logit framework for differentiated products, following Berry et al. (1995) and Nevo (2001).

Within each country c, a representative individual i chooses to purchase a drug j from the set of choices $j = 0, 1, .., J_{m(j)}$ available in j's market, according to the indirect utility:[10]

$$U_{ijt} = u_{ijt} + \varepsilon_{ijt}$$

where

$$u_{ijt} = \alpha_i \ln p_{jt} + \beta_{im(j)} g_j + \gamma_i + \lambda_{m(j)} x_{jt} + \phi_j + \mu_{m(j)t} + \xi_{jt}.$$

We normalize the utility for the outside good (choosing not to purchase anything), u_{i0t}, to zero. We denote p_{jt} for the price of drug j at t. Drug characteristics are captured by the drug's molecule identifier, patent status and generic status. In our utility specification, g_j is a binary variable indicating whether drug j is generic, x_{jt} is a binary variable indicating whether j's molecule patent has expired by quarter t and ϕ_j is a molecule fixed effect. An unobserved shock at the drug-quarter level is denoted by ξ_{jt}.

Consumer preferences are captured by three types of random effects. Individual value for purchasing an inside good is captured by the random effect γ_i. Individual disutility from higher prices is captured by the random coefficient α_i on log prices.[11] Individual preference for branded drugs is captured by the random coefficient β_{im} on the branded indicator variable. We assume that random coefficients are independently normally distributed with $\alpha_i \sim \mathcal{N}(\alpha, \sigma_\alpha)$, $\beta_{im} \sim \mathcal{N}(\beta_m, \sigma_\beta)$, $\gamma_i \sim \mathcal{N}(0, \sigma_\gamma)$, and denote the vectors of parameters $\theta = (\sigma_\alpha, \sigma_\beta, \sigma_\gamma)$. The mean utility for drug j in quarter j is thus given by

$$\delta_{jt} = \alpha \ln p_{jt} + \beta_{m(j)} g_j + \lambda_{m(j)} x_{jt} + \phi_j + \mu_{m(j)t} + \xi_{jt}.$$

[10] All parameters and variables in the utility function, as well as the choice set within an ATC-4 class, are country-specific. We suppress the country index c for ease of exposition. Since each drug is only available in one ATC-4 class, we also suppress the m subscript in market denotations. That is, we consider the demand model country by country, and each unique market that a drug j is available in is denoted by t.

[11] We use a log price specification that fits better the data because we have very heterogeneous prices across different ATC-4 markets. While widely used in the literature (Björnerstedt and Verboven, 2016; Gowrisankaran and Rysman, 2012; Berry et al., 1995), it is known that this specification does not correspond to a closed form solution for its direct utility function.

Assuming that ε_{ijt} is i.i.d. extreme value distributed, the expected market share of product j in market mt where $m = m(j)$ is given by the aggregate probability that j will be chosen from the choice set in m:

$$s_{jt}\left(\delta_{jt}, \theta\right) = \int \frac{\exp\left(u_{ijt}\right)}{1 + \sum_{k=1}^{J_m} \exp\left(u_{ikt}\right)} dF(\nu_{im}; \theta) \tag{3.1}$$

where ν_{im} denotes the vector of random coefficients $\{(\alpha_i - \alpha), (\beta_{im} - \beta_m), \gamma_i\}$ and $F\left(.; \theta\right)$ denotes their joint c.d.f.

3.2 Demand Identification

We estimate our demand model according to the standard BLP method with instrumental variables for prices (Berry et al., 1995). We construct drug-quarter demand shocks $\xi_{jt}(\delta_{jt}, s_{jt}, \theta)$ by inverting a system that matches the theoretical market shares in equation (3.1) to observed market shares. We then form moment conditions by interacting the inverted demand shocks with a set of orthogonal instruments Z_{jt} so that

$$\mathbb{E}\left[Z_{jt}\xi_{jt}(\delta_{jt}, s_{jt}, \theta)\right] = 0.$$

The key challenge to estimation is the consistent estimation of the price coefficient distribution. We expect the process of price-setting to be affected by unobserved demand shocks ξ_{jt}, and so observed prices are likely to be correlated with $\xi_{jt}(\delta_{jt}, s_{jt}, \theta)$. Our identification thus depends on the use of instruments that affect prices but are orthogonal to ξ_{jt}. While the gold standard would be to collect direct cost-shifters for each drug, this is impractical for our exercise. In order to assess the effect of an international reference pricing policy on total hospital drug spending, we examine a large number of drugs across a large number of therapeutic classes. As such, it is unlikely that we would be able to find detailed cost-shifters that are relevant to all of the classes of drugs that we cover. Similarly, it would be unfeasible to collect specific cost-shifters for each drug or therapeutic class. One possibility would be to restrict our analysis to a few therapeutic classes, find class-specific cost shifters and identify the price coefficient only off of those therapeutic classes. However, this would limit the scope of our empirical assessment.

Instead, we leverage observed differences and changes in consumers' choice sets from quarter to quarter as our primary source of identification. In particular, we form instruments by collecting, for each drug j in each quarter t, the number of products in j's ATC-4 class, its (broader) containing ATC-3 class, the numbers of generics and off-patent branded drugs, both for j's molecule and in general within j's therapeutic class, and the number of countries (out of France, Germany, Canada, Spain, Italy, the UK and the US) in which j is offered in the hospital sector.

These variables capture variation in the composition of drug j's competition that is largely driven by the entry of new drugs, the expiration of patents, and the exit of outdated drugs. Similarly to BLP instruments, identification is premised on the assumption that isolation in the product space predicts prices through the competitive channel. Similar logic may still hold even if prices are set through bargaining: products that are innovative and without clear substitutes may be able to extract more rent when bargaining. Moreover, while changes in the competitive landscape for drug j is thus likely to impact its price, the changes themselves are largely driven by the ascendance of time and technological progress. Drugs often face delays in entering markets outside the US due to additional regulatory hurdles. Furthermore, patent protection is determined long in advance and entry decisions can take years. Even generic entries often face delays from regulations, start-up costs, etc. and so they provide an additional source of choice set variation. As such, it is unlikely that any of these instruments will correlate with the idiosyncratic demand shocks ξ_{jt}.

In addition to checking the power of instrumental variables in a first stage regression, we consider using Hausman style instruments, as in Dubois and Lasio (2018). Identification using such instruments relies on the correlation between prices across markets due to common cost shocks rather than common demand shifters. To construct such instrumental variables, we perform country-level regressions of price on active ingredient dummies and quarter fixed effects, and we use the residuals as instruments for price. The instruments for the price of product j in market $m(j)$ are the contemporaneous residuals for the price of product j in other countries. As an example, we instrument for the price of the drug Sovaldi in the United States using the price residuals of Sovaldi in France, Germany, Canada, Spain, Italy, and the UK. The reason we use residuals as instruments is that these allow us to control for temporal, regional, and quality components that may contribute to contemporaneous demand-based variation in prices. We also allow for different relationships across countries for brand name drugs and generic drugs. We take additional care for producers with multiple drugs or for the fact that some drugs are available in only a subset of countries. When a product is not available in all other countries, we use residuals from available countries. When a product is available in only one country, we use the average residuals of other products within the same ATC in other countries as instruments. The main possible concern is that there is insufficient variation in these instruments to precisely identify price sensitivity, but this is again an empirical question of the power of instrumental variables, and we investigate this in our empirical estimates.

Finally, it is important to note that the estimation of BLP-type demand models requires the definition of market shares for products within each market. Quantities of drugs sold and

normalized by standard units allow us to construct market shares but require the definition of a market size. Market sizes across many ATC-4 markets and across countries for the hospital sector are not obviously defined and can change over time and be very different. However, we do not observe an external estimate of market sizes, nor of the outside share (which would be equivalent). Instead, we approximate the aggregate yearly market size denoted by M_{mt} for each ATC-4 market using a nonlinear least squares calibration procedure similar to that in Huang and Rojas (2013, 2014). We describe this procedure in detail in Appendix 7.2.1. On average, we find that the estimated outside market share is 29% in Canada and 24% in the US with some variation across ATC-4 classes (see detailed estimates in Appendix 7.2.2).

3.3 Empirical Results on Demand Estimation

We present key estimated demand parameters for the US and Canada in Table 3.1. We find that the random coefficients on log prices in Canada and the US have similarly negative means. The standard deviation of the price coefficient in Canada shows substantial heterogeneity. There are a number of reasons that might underlie this. One of them is that price sensitivity may vary across providers or for the same provider across patients with different disease severities and therefore willingness to pay for drugs. The random coefficient on generic preference can also represent heterogeneity in hospitals' purchasing policies and brand preferences.

We also find differences in the dimension of preference heterogeneity between Canada and the US. In the US, our estimate of the random coefficient on the generic indicator suggests that there is substantial heterogeneity in preferences for branded drugs. By contrast, in Canada, much of the heterogeneity in demand is captured in the constant term and is thus common to all drugs. We account for molecule fixed effects, ATC-4 specific year effects, and ATC-4 specific off-patent and generic effects as well, but do not report this for the sake of exposition.

Table 3.1: *Demand Estimates for US and Canada*

Country		US		Canada	
Log Price	α	-2.254	(0.146)	-2.241	(0.206)
	σ^{α}	0.024	(0.246)	0.892	(0.224)
Generic Dummy	σ^{β}	1.628	(0.169)	0.357	(1.195)
Constant	σ^{γ}	0.042	(1.103)	1.562	(0.312)
Molecule dummies		Yes		Yes	
Off patent * ATC-4 dummies		Yes		Yes	
Generic * ATC-4 dummies		Yes		Yes	
Year * ATC-4 dummies		Yes		Yes	
Quarter dummies		Yes		Yes	

Note: Standard error in parenthesis. All dummy coefficients are not reported.

We present the average own- and cross-price elasticities for hospitals in the US and Canada in Table 3.2. These elasticities are computed using our estimated demand function in every country, ATC-4 market and quarter. We present the average elasticities across ATC-4 classes and quarters within each country, in aggregate and by branded status. Overall, average price elasticities are similar between the US and Canada. However, own-price elasticities are slightly higher for generics than branded drugs in Canada, suggesting that hospitals in Canada are more responsive to price changes in generic drugs.

Table 3.2: *Average Price Elasticities for Canada and US*

	US		Canada	
	Own	Cross	Own	Cross
All	-2.033	0.124	-2.017	0.158
Branded	-2.044	0.155	-1.809	0.185
Generic	-2.021	0.147	-2.262	0.163

Note: Average own price elasticities across all products of ATC-4 markets and over quarters.

4 Supply Side Modeling and Estimates

4.1 Price setting with Bargaining

We model price setting for pharmaceuticals in Canada with a Nash Bargaining model in which firms maximize profits, while government regulators maximize consumer welfare. Nash Bargaining models of this sort (see for instance, Crawford and Yurukoglu (2012); Grennan (2013); Gowrisankaran et al. (2015); Ho and Lee (2017)) provide a parsimonious way to characterize the trade-offs facing policy-makers, who must balance producer profits against consumer welfare. In Canada, this bargaining may be interpreted literally, as the Canadian Patented Medicine Prices Review Board negotiates prices with drug manufacturers to ensure that they are not "excessive". Moreover, this model applies more generally to price-regulated pharmaceutical markets such as those in most European countries, absent international reference pricing. We assume that there is no international reference pricing (in the baseline), and so pricing is determined independently within each country. We thus exclude a country-specific index for exposition.

Firm profits are defined as follows. Within a market m at time t, firm f selling products $j \in F_{fm}$ receives flow profits:

$$\Pi_{fmt} \equiv \sum_{j \in F_{fm}} \Pi_{jmt} \equiv \sum_{j \in F_{fm}} (p_{jt} - c_{jt}) q_{jt}(\mathbf{p}_{mt}).$$

Here, c_{jt} and p_{jmt} are the marginal cost and price of drug j, respectively. Their difference (the firm's markup) multiplies q_{jt}, the total quantity of drug j demanded in market m, given the vector of prices $\mathbf{p}_{mt} = (p_{1t}, .., p_{J_m t})$ of drugs available in the market.[12] Firm f's total profit is the sum of its profits across markets:

$$\Pi_{ft} \equiv \sum\nolimits_m \Pi_{fmt}.$$

Government regulators maximize aggregate consumer welfare as revealed by the demand model in their country. We denote the welfare for consumers in market m at period t by: (Small and Rosen, 1981):

$$\begin{aligned} W_{mt}(\mathbf{p}_{mt}) &= M_{mt} \int W_{imt}(\mathbf{p}_{mt}) dF(\nu_{im};\theta) = M_{mt} \int \ln\left[1 + \sum\nolimits_j \exp\left(u_{ijt}\right)\right] dF(\nu_{im};\theta) \\ &= M_{mt} \int \ln\left[1 + \sum\nolimits_j \exp\left(\alpha_i \ln p_{jt} + \beta_{im} g_j + \gamma_i + \lambda_m x_{jt} + \phi_j + \mu_{mt} + \xi_{jt}\right)\right] dF(\nu_{im};\theta). \end{aligned}$$

That is, consumer welfare is given by the sum of the expected utility produced by each drug available in market m. We assume that bargaining takes place product-by-product, so that neither firms nor regulators are able to bargain jointly over their portfolio of pharmaceutical drugs. This is made for simplicity as most firms own only one drug per ATC4 class and excludes the possibility of using bundling arrangements across ATC4 classes. Thus, at each market m and quarter t, prices are set product-by-product via Nash bargaining between the producer and the market m regulator, in order to maximize the Nash product of firm profits and consumer welfare:

$$\underbrace{\left(\Delta_{jm}\Pi_{ft}\left(p_{jt}, \mathbf{p}_{-jmt}\right)\right)^{\rho_{jm}}}_{\text{Profit from } j \text{ in } m} \underbrace{\left(\Delta_j W_{mt}(p_{jt}, \mathbf{p}_{-jmt})\right)^{1-\rho_{jm}}}_{\text{Welfare gain from } j \text{ in } m}.$$

Here, $\rho_{jm} \in [0, 1]$ is the bargaining parameter that determines the relative weight of the firm's (profit) objective in determining the Nash bargaining solution. In order to account for heterogeneity in the bargaining process across drug types, we allow ρ_{jm} to vary across ATC-4 markets and by each drug's status as on-patent, branded off-patent or generic. The firm's objective is defined as the equilibrium profit generated by offering drug j at price p_{jt}:

$$\Delta_{jm}\Pi_{ft}(p_{jt}, \mathbf{p}_{-jmt}) \equiv \Pi_{ft} - \sum\nolimits_{j' \neq j, j' \in F_f} \Pi_{j'm(j')t} = \Pi_{jmt}(p_{jt}, \mathbf{p}_{-jmt}),$$

[12] Note that the quantity demanded is given by the size of the market multiplied by drug j's market share: $q_{jt} = M_{mt} s_{jt}$.

where $\mathbf{p}_{-jmt}$ denotes the vector of prices for all drugs other than j in market m and quarter t. Note that this is just the profit directly accrued from the sale of drug j, as we have assumed that the few firms who own several drugs per market do not take into account substitution across different drugs in their portfolios when setting prices. Similarly, $\Delta_j W_{mt}(p_{jt}, \mathbf{p}_{-jmt})$ denotes the change in consumer welfare generated by the presence of drug j in market m and quarter t:

$$\Delta_j W_{mt}(p_{jt}, \mathbf{p}_{-jmt}) \equiv W_{mt}(p_{jt}, \mathbf{p}_{-jmt}) - W_{mt}(\infty, \mathbf{p}_{-jmt}).$$

where $W_{mt}(\infty, \mathbf{p}_{-jmt})$ denotes by convention the welfare when j is absent of the market. We assume a Nash-in-Nash equilibrium. That is, the vector of competitor prices in the vector $\mathbf{p}_{-jmt}$ in the case of disagreement are assumed to be equal to the equilibrium prices. Thus, for each drug $j = 1, .., J_m$, the equilibrium price is set according to:

$$p_{jt} \equiv \arg\max_{\tilde{p}_{jt}} \quad \left\{ \Pi_{jmt}(\tilde{p}_{jt}, \mathbf{p}_{-jmt})^{\rho_{jm}} (\Delta_j W_{mt}(\tilde{p}_{jt}, \mathbf{p}_{-jmt}))^{1-\rho_{jm}} \right\}. \tag{4.1}$$

The necessary first-order conditions of the Nash bargaining equilibrium definition in equation (4.1) imply that for all $j = 1, .., J_m$:

$$c_{jt} = p_{jt} + \frac{1}{\underbrace{\frac{\partial \ln q_{jt}(\mathbf{p}_{mt})}{\partial p_{jt}}}_{\text{Demand semi-elasticity}} + \frac{1-\rho_{jm}}{\rho_{jm}} \underbrace{\frac{\partial \ln \Delta_j W_{mt}(\mathbf{p}_{mt})}{\partial p_{jt}}}_{\text{Welfare semi-elasticity}}}$$

where

$$\frac{\partial \Delta_j W_{mt}(\mathbf{p}_{mt})}{\partial p_{jt}} = \frac{\partial W_{mt}(\mathbf{p}_{mt})}{\partial p_{jt}} = M_{mt} \int \frac{\partial W_{imt}(\mathbf{p}_{mt})}{\partial p_{jt}} dF(\nu_{im}; \theta) = M_{mt} \int s_{ijt} \frac{\partial u_{ijt}}{\partial p_{jt}} dF(\nu_{im}; \theta) \tag{4.2}$$

Note that when $\rho_{jm} = 1$, pricing is set according to an unrestricted Bertrand-Nash equilibrium in prices where firms maximize profits and (4.1) simplifies to the usual condition:

$$c_{jt} = p_{jt} + \frac{q_{jt}(\mathbf{p}_{mt})}{\partial q_{jt}(\mathbf{p}_{mt}) / \partial p_{jt}} \tag{4.3}$$

In such a case, an estimate of c_{jt} is straightforward to compute given demand parameter estimates. In the case of the US, we will use this special case to identify marginal costs, as we know that there is no central regulation of hospital prices akin to a bargaining game as in Canada. When $\rho_{jm} = 0$, we have price equal to marginal cost $p_{jt} = c_{jt}$.

4.2 Supply Side Parameters Identification and Estimation

The set of first-order conditions (4.1) relates marginal costs to the shape of demand, drug prices, and the bargaining parameters ρ_{jm}. With known bargaining parameters, these first-order conditions allow us to identify the vector of marginal costs c_{jmt} as functions of ρ_{jm}.

As we noted before, in the US, we assume that $\rho_{jm} = 1$ because prices are freely chosen and not regulated for the hospital sector.[13] In that case, the first-order conditions simplify to the usual Bertrand-Nash first-order conditions (4.3) and allow identifying all marginal costs, which we denote c_{jUSt} for a product j in a market belonging to the US as in Nevo (2001). For generics in the US, we impose that prices equal to marginal costs and do not estimate margins, which is consistent with the typical fact that once many generics have entered, prices are low and close to marginal costs.

In Canada, prices are set through bargaining and so we must identify the bargaining parameters ρ_{jm} in addition to marginal costs using equations (4.1). Without any restriction on marginal costs, we cannot identify marginal costs and bargaining parameters. We could use sign restrictions on marginal costs and markups in order to obtain lower and upper bounds on the bargaining parameter. However, it is natural to add restrictions based on parameterization to marginal costs functions as in Berry et al. (1995). One way to identify costs and bargaining parameters is to let marginal costs be constant over time, constant across countries, or both. We assume that marginal costs can be parameterized as additively separable functions of supply-side covariates and an orthogonal error term as follows:

$$c_{jt}\left(\rho_{jm(j)}\right) = z'_{jt}\lambda + \omega_{jt} \tag{4.4}$$

with

$$\mathbb{E}\left[z_{jt}\omega_{jt}\right] = 0 \tag{4.5}$$

and where $c_{jt}\left(\rho_{jm(j)}\right)$ is solution of (4.1). In our application, z_{jt} include a molecule-specific and country-time-specific effect as well as the estimated US marginal cost c_{jUSt} from (4.3). We thus have further identification power by leveraging our assumption that pricing is known to be set through an unconstrained Bertrand-Nash pricing game for all products sold in the US (excluding Federal sales).

[13] Notable exceptions to unconstrained pricing include pharmaceutical sales to the "Big Four:" Department of Veteran Affairs ($3.4 billion in 2003), Department of Defense ($4 billion in 2003), Public Health Service, and the Coast Guard, which receive discounted drug prices negotiated with manufacturers. Medicaid also receives effective discounts, but these are in the form of ex post rebates paid directly to the state rather than lower prices paid at the register. Medicare, on the other hand, is prohibited from negotiating prices.

The orthogonality conditions (4.5) allow to define for any market m in Canada and all j such that $m(j) = m$:

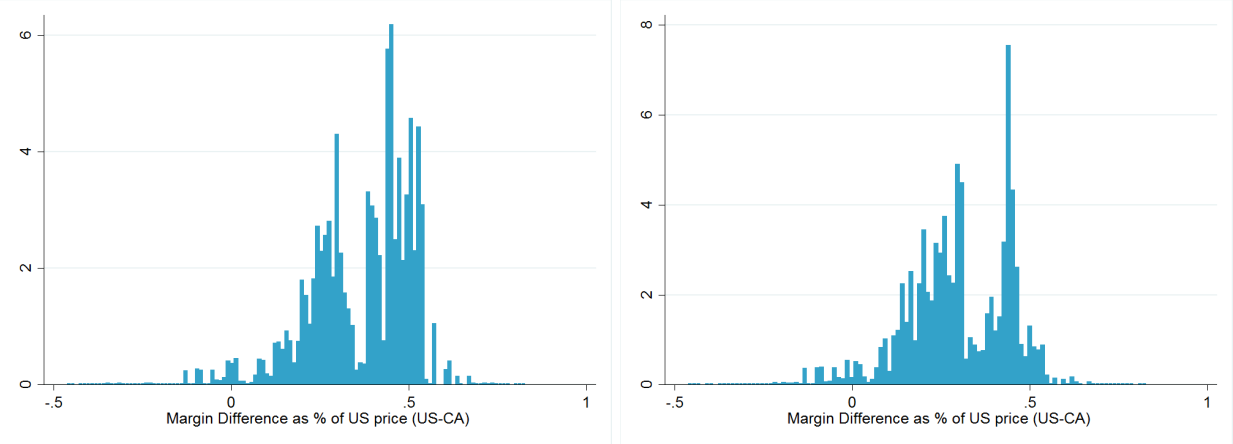
$$\omega_{jt}(\rho_{jm}) = \left[1 - z'_{jt}\left(z'_{jt}z_{jt}\right)^{-1} z'_{jt}\right] c_{jt}(\rho_{jm})$$

Thus, we solve for any ATC-4 class m in Canada:

$$\{\rho_{jm}\}_{\{j=1,..,J\}} = \arg \min_{\{\rho_{jm}\}_{\{j=1,..,J\}}} \sum\nolimits_{j,t} \omega_{jt}^2(\rho_{jm}) \tag{4.6}$$

Table 7.3 in Appendix 7.3 shows the estimated average margins in percentage of the maximum average price of US and Canada (which is almost always the US) by ATC-4 class so that we can compare them across countries. The results show relatively large margins—which is not surprising in the case of pharmaceuticals. We also find that the margins are larger in the US than in Canada for most drugs. Figure 4.1 draws the distribution of the differences of margins between US and Canada as a percentage of the US price, weighting the distribution either by quantity sold in the US or in Canada. The difference is most often positive as very few drugs have higher margins in Canada than in the US. The graph shows that many of products have margins in the US that are larger than in Canada by an amount that is more than 25% of the US price and up to 50%, which can mean extremely large differences in absolute dollars according to the US price level.

Figure 4.1: *Estimated Margins Differences between US and Canada for on Patent Drugs*



Note: The left panel shows the distribution of margins differences weighted by the US quantities of the drug. The right panel shows the distribution of margins differences weighted by the Canadian quantities of the drug. These distributions are for the sample of on-patent drugs present in both the US and Canada.

The supply model estimates also provide bargaining parameters estimates for Canada, as shown in Table 7.4 in Appendix 7.3. The parameters vary between 0 and 1.

5 Counterfactual Policies

In this section, we use our structural model to evaluate the impact of several counterfactual international reference pricing policies. The primary reference pricing rule we consider prohibits pharmaceutical companies from setting higher prices for on-patent drugs in the United States than in Canada. In other words, this rule requires that for any on-patent drug j sold in both the United States (US) and Canada (CA):[14]

$$p_j^{US} \leq p_j^{CA}. \tag{5.1}$$

This type of policy is often referred to as an "international reference pricing" policy, or a "most favored nation" clause. The stated objective of such a rule is typically to reduce prices in the referencing country since they ensure that prices paid in the referencing country (United States) are at least as low as those in the reference country (Canada). In equilibrium, however, reference pricing rules can also affect the price in the referenced country. In particular, profit-maximizing pharmaceutical companies may set or negotiate rates in the referenced country taking into account the impact on the price they can set in the referencing country. We incorporate this interdependence by allowing negotiations between pharmaceutical companies and Canada to account for the impact of the Canadian price on potential profit in the United States.

We present our primary counterfactual specification in Section 5.1. In this counterfactual we allow the Canadian price to act as a *price ceiling* in the United States. Implicitly, this assumes that the pharmaceutical company cannot commit to a price in the United States prior to negotiation with Canada. This can equivalently be seen as a timing assumption that prices are set in Canada prior to being set in the United States. The main specification of this counterfactual is in section 5.1.1. Section 5.1.2 then shows what would happen if the reference country (Canada) was larger in size or if the reference price was allowing a premium.

Because the implications of reference pricing policy may depend on the specific details of implementation, we also study alternative counterfactual specifications. The first of these variants is to allow the firm to commit to a price in the United States prior to negotiating with Canada. In this case, the price in the United States behaves as a *price floor* in the firm's negotiations with Canada. We include simulations for this counterfactual in Section 5.2.1.

[14] To simplify notation, we exclude the time and drug-class subscripts in this section.

5.1 Counterfactual with Reference Pricing as Price Ceiling

5.1.1 International Reference Pricing with Canada

When the negotiated price in Canada acts as a price-ceiling, pharmaceutical companies set prices in the United States to maximize profits subject to that ceiling:[15]

$$p_j^{US}(p_j^{CA}, \mathbf{p}_{-j}^{US}) \equiv \arg \max_{p \in [0, p_j^{CA}] \cup \{\infty\}} \Pi_j^{US}\left(p, \mathbf{p}_{-j}^{US}\right) \mathbf{1}_{\{p \leq p_j^{CA}\}}. \tag{5.2}$$

This defines a correspondence giving the firm's optimal price in the United States given its price in Canada and other products' prices in the United states. The Nash equilibrium solution are then prices $p_j^{US*}(\mathbf{p}^{CA})$ where $\mathbf{p}^{CA} = (p_j^{CA}, \mathbf{p}_{-j}^{CA})$ is the vector of all prices in Canada. Remark that US price under reference pricing $p_j^{US*}(p_j^{CA}, \mathbf{p}_{-j}^{CA})$ can be lower than the unconstrained price $p_j^{US*}(\infty, \infty)$ even if this unconstrained price was lower than the initial Canadian price ($p_j^{US} \leq p_j^{CA}$) because of the constraint effects on competing drugs and the strategic complementarity of drugs within a market.

We allow negotiations between pharmaceutical companies and the Canadian regulator to account for the impact of the Canadian price on profitability in the United States. Given negotiated price p_j^{CA} in Canada, the pharmaceutical company expects to earn $\Pi_j^{CA}(p_j^{CA}, \mathbf{p}_{-j}^{CA})$ in Canada and $\Pi_j^{US}(p_j^{US*}(p_j^{CA}, \mathbf{p}_{-j}^{CA}), \mathbf{p}_{-j}^{US})$ in the United States, where $p_j^{US*}(p_j^{CA}, \mathbf{p}_{-j}^{CA})$ is the Nash equilibrium from (5.2). The agreement surplus for the firm in negotiation in Canada is therefore:

$$\Delta\Pi_j(p_j^{CA}, \mathbf{p}_{-j}^{US}, \mathbf{p}_{-j}^{CA}) \equiv \underbrace{\Pi_j^{US}(p_j^{US*}(p_j^{CA}, \mathbf{p}_{-j}^{CA}), \mathbf{p}_{-j}^{US}) + \Pi_j^{CA}(p_j^{CA}, \mathbf{p}_{-j}^{CA})}_{\text{global profit under agreement}} - \underbrace{\Pi_j^{US}(p_j^{US*}(\infty, \mathbf{p}_{-j}^{CA}), \mathbf{p}_{-j}^{US})}_{\text{profit if in US only}}. \tag{5.3}$$

Following Horn and Wolinsky (1988), the negotiated price in Canada maximizes the Nash product:

$$p_j^{CA}(\mathbf{p}_{-j}^{US}, \mathbf{p}_{-j}^{CA}) \equiv \arg\max_p \left(\underbrace{\Delta\Pi_j(p, \mathbf{p}_{-j}^{US}, \mathbf{p}_{-j}^{CA})}_{\text{profit gain from agreement}} \right)^{\rho_j} \left(\underbrace{\Delta_j W_{CA}(p, \mathbf{p}_{-j}^{CA})}_{\text{welfare gain in CA from agreement}} \right)^{1-\rho_j}. \tag{5.4}$$

[15] We again use $p_j^{US} = \infty$ to denote exit from the United States market. This occurs when $p_j^{CA} < c_j^{US}$. This is most plausible as an equilibrium outcome when the Canadian market is large, Canadian consumers are price sensitive, and marginal cost is very low, while the US market is small, US consumers are price sensitive, and marginal cost is very high in the United States.

In equilibrium, the prices for on-patent drugs sold in both the United States and Canada satisfy (5.2) and (5.4), respectively.[16] In other words, equilibrium prices $\{(p_j^{US*}, p_j^{CA*})\}_j$ are characterized by:

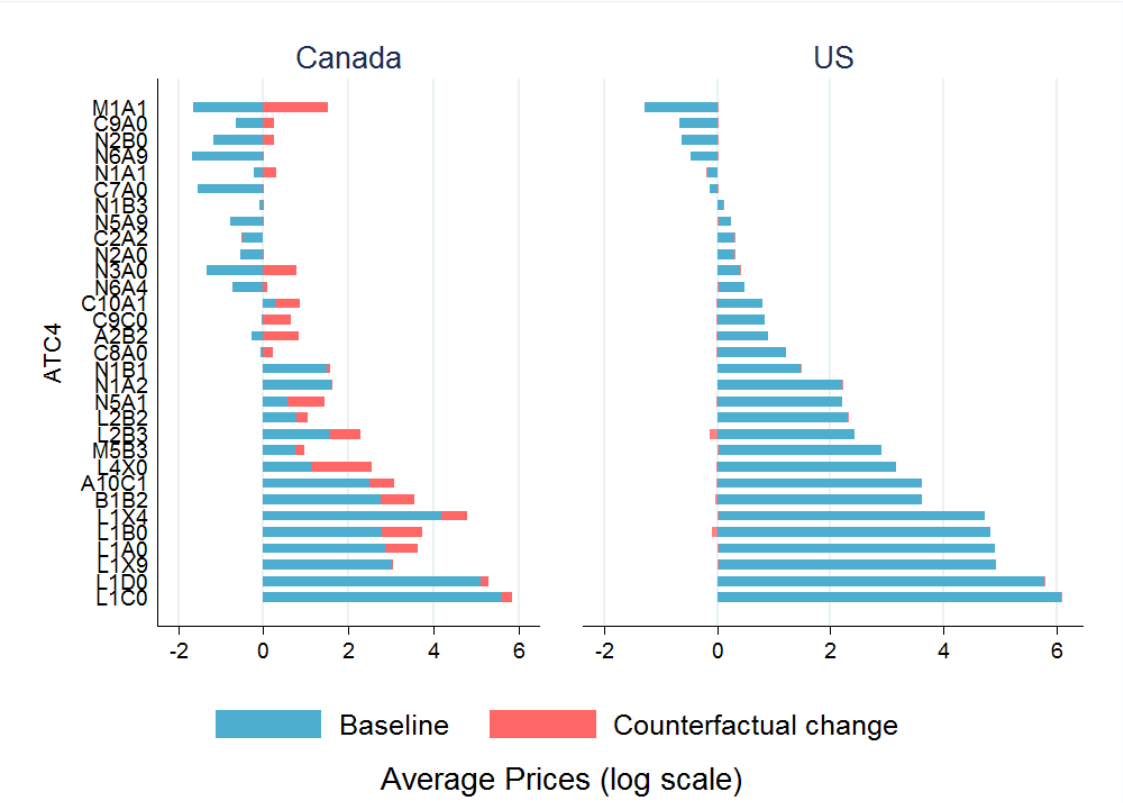
$$\begin{aligned} p_j^{US*} &= p_j^{US}(p_j^{CA*}, \mathbf{p}_{-j}^{US*}), \\ p_j^{CA*} &= p_j^{CA}(\mathbf{p}_{-j}^{US*}, \mathbf{p}_{-j}^{CA*}), \end{aligned} \tag{5.5}$$

Considering this model of price setting in a regulated country with price bargaining and a country that implements such international reference pricing constraint, under simplifying assumption of concavity of the profit function of each firm in its own price and strategic complementarity in prices across firms, we can show that prices in the US necessarily decrease (or stay the same) and prices in Canada necessarily increase (or stay the same). We prove this in Appendix 7.4 in the generic case where solutions are always interior and no firm exits the market. However, as exits may happen in particular because costs may differ across countries, price variations may be different. Moreover, the effectiveness of an International Reference Pricing will depend crucially on the magnitude of price variations across countries.

Using our estimates for the parameters governing supply and demand from sections 3 and 4, we simulate price setting in the US and Canada without reference pricing. In each therapeutic class, we simulate equilibrium bargaining in Canada, drug by drug, and Bertrand price-setting in the US, subject to the reference pricing policy detailed in Section 5.1. Although the reference constraint applies only to patented drugs, we also simulate the pricing decisions for generic and branded off-patent drugs since their optimal pricing decisions are likely to change when on-patent competitors change prices. The graphs in this section therefore include off-patent drugs in addition to on-patent drugs unless otherwise stated.

[16] The usual profit maximization and Nash bargaining conditions must also be satisfied for all other products in the US and Canada.

Figure 5.1: *Counterfactual Prices with Canada as Price Ceiling*



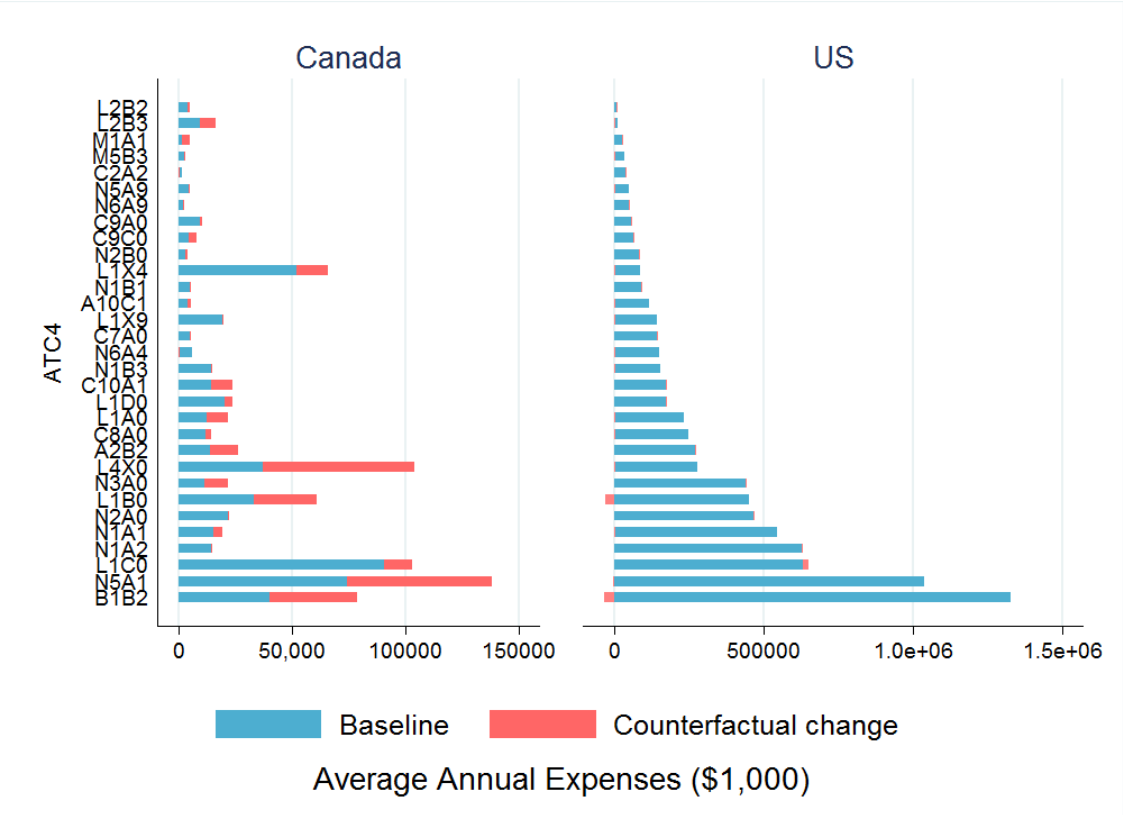
Note: Each blue bar indicates the log of average prices in each ATC-4 class in the baseline without reference pricing. The red bar indicates the change in log average prices resulting from imposing reference pricing. A red bar to the right of the blue bar indicates that prices increased by the length of the red bar. A red bar to the left of the blue bar indicates that prices decreased by the length of the red bar. ATC4 classes are ordered from the top to down by value of average price in the US. Price being in US$1000, the zero of horizontal axis means an average price of US$1000 per standard unit.

To evaluate the effects of our counterfactual, we consider several measures of impact. First, we consider the impact of counterfactuals on the prices of pharmaceuticals in both the United States and Canada. Figure 5.1 compares average prices by therapeutic class (weighted by quantity) in the baseline to those that result from the introduction of reference pricing. We find that while the reference pricing policy leads only to a slight reduction in US prices, it leads to significant increases in Canadian prices. Looking at the equilibrium prices per drug, the reference pricing rule results in a binding price constraint (i.e., $p_j^{US} = p_j^{CA}$) and equilibrium prices very close to the baseline United States prices. As such, they illustrate the dominant mechanism through which prices change when reference pricing is imposed: US prices of on patent drugs decrease slightly, while Canadian prices of the same drugs rise to match them. As most Canadian prices are substantially lower than US prices in the baseline, rising to near baseline US levels constitutes a large increase. Moreover, generics or branded off patent drugs will generally increase their price in Canada too and decrease slightly in the US. As we show next, this increase in Canadian prices dominates the quantity response, so that expenditure and profits both increase.

If one examines a few examples in significant therapeutic classes, one can see that the price changes are really important. As a first case, we examine the Atypical Antipsychotics class (N5A1), which constitutes 14.8% of expenditures in the United States and 13.1% of expenditures in Canada, among the therapeutic classes we analyze. The impact of introducing the reference pricing rule on Canada is substantial: expenditures and profits increase by 85.8% and 91.1%, respectively. By comparison, these figures decrease by just 0.5% and 1.2% in the United States. Similarly, welfare decreases by 24.1% in Canada, and increases by only 0.7% in the US. Driving these results, the equilibrium prices in both markets under the reference pricing rule are much closer to the baseline prices in the United States. For example, the prices of on-patent drugs Apriprazole, Olanzapine, Quetiapine, and Risperidone—all part of the N5A1 ATC-4 class—increase by hundreds of percent in Canada to near-parity with the baseline United States price since US prices only very slightly decrease. Another key example is the Vinca Aklaloid class (L1C0), a class of chemotherapy drugs which constitutes 4.79% of expenditures in the US and 10.8% of expenditures in Canada. This class has a large concentration of patented drugs—4 out of 12 in the US and 3 out of 11 in Canada. Taking the example of Docetaxel in this class, while the Canadian price is approximately half of the US price in the baseline, the prices are equal, at a level slightly below the baseline US price in the counterfactual. This is true on aggregate for patented drugs in L1C0: average drug prices increase in Canada by 66.1% but decrease in the US by 4.6%.[17] However, total expenses increase both in Canada (13.7%) and in the US (3.2%), reflecting a slight increase in US prices for branded off-patent drugs. Aggregate average profits and welfare follow the general pattern found across therapeutic classes: profits increase substantially (44.7%) in Canada, but decrease slightly (1.5%) in the US, while welfare decreases substantially (9.6%) in Canada and increases slightly (1.4%) in the US.

[17] See Table 7.10 in Appendix 7.5.1 for a breakdown of price changes by ATC-4 and drug status.

Figure 5.2: *Counterfactual Expenses under Price Ceiling*



Note: Each blue bar indicates the average annual expenditure in each ATC-4 class in the baseline without reference pricing. The red bar indicates the change in average annual expenditure resulting from imposing reference pricing. A red bar to the right of the blue bar indicates that expenditure increased by the length of the red bar. A red bar to the left of the blue bar indicates that expenditure decreased by the length of the red bar.

Figures 5.2, 5.3, and 5.4 depict the effect of the reference pricing rule on expenditures, profits, and welfare by therapeutic class. Tables of numerical values are given in Appendix 7.5.1. While there is significant variation across ATC-4 classes, our results show that expenditures and profits overwhelmingly increase (60.6% and 65.6%, respectively) in Canada while Canadian consumer welfare decreases (12.3%). The impacts are significantly smaller but generally reversed for the United States.[18] Expenditure and profits in the United States decrease by 0.75% and 1.9%, respectively, while welfare increases 0.2%. In our simulations, four on-patent drugs from four ATC-4 classes choose to exit from the United States market.[19] However, these products represent small market shares and small expenditure, suggesting that reference pricing does not generate large market distortions by incentivizing drug exits.[20] The results in the class of statins (C10A1)

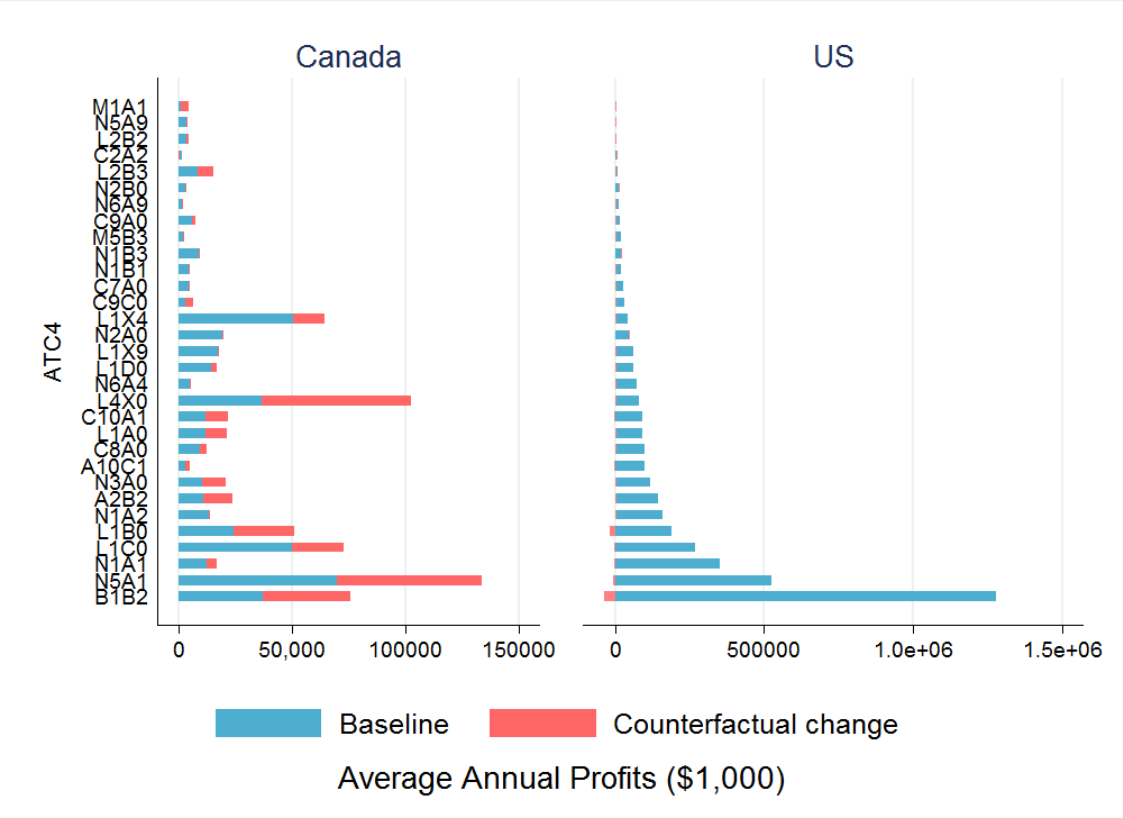
[18] It is worth noting that expenditure increases in the United States for a few ATC-4s, suggesting that substitution patterns may dominate small price decreases in these markets.

[19] Firms never choose to exit the Canadian market since given the firm's US price, a sufficiently high Canadian price always exists that generates positive profit and allows the reference price constraint to be satisfied.

[20] The largest is in the anti-rheumatics therapeutic class (M1A1) and combines Diclofenac with Misoprostol. This product represents 4.8% of average expenses in the class, and exits between 2008 and 2011. The other drugs that exit are the ATC-4 classes A10C1, B1B2, and C9A0, and have expenditure shares between 0.1% and 1.5%.

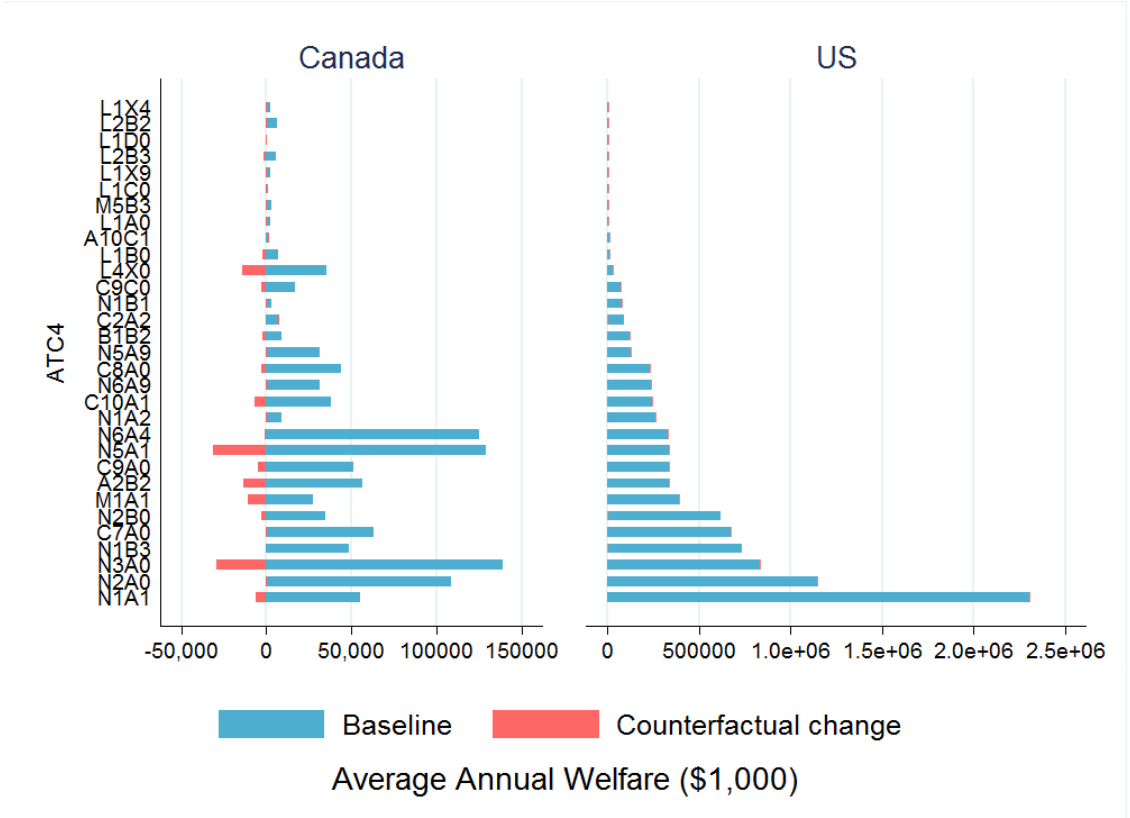
that Rosuvastatin belongs to, and the class of beta-blockers (C9C0) that Valsartan belongs to are similar.

Figure 5.3: *Counterfactual Profit Changes on All Drugs with Canada as Price Ceiling for the US*



Note: Each blue bar indicates the average annual profits in each ATC-4 class in the baseline without reference pricing. The red bar indicates the change in average annual profits resulting from imposing reference pricing. A red bar to the right of the blue bar indicates that profits increased by the length of the red bar. A red bar to the left of the blue bar indicates that profits decreased by the length of the red bar.

Figure 5.4: *Counterfactual Welfare Changes on All Drugs with Canada as Price Ceiling for the US*

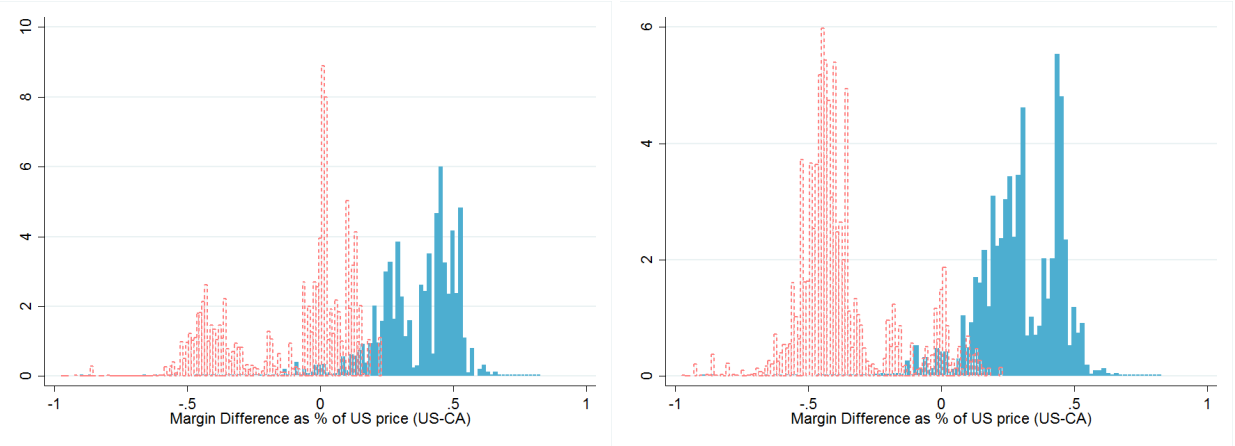


Note: Each blue bar indicates the average annual welfare in each ATC-4 class in the baseline without reference pricing. The red bar indicates the change in average annual welfare resulting from imposing reference pricing. A red bar to the right of the blue bar indicates that welfare increased by the length of the red bar. A red bar to the left of the blue bar indicates that welfare decreased by the length of the red bar.

Analogously to Figure 4.1, Figure 5.5 shows the difference for on patent drug margins in the United States and Canada both in the baseline and under the reference pricing counterfactual. This figure shows that the international reference pricing policy results in generally higher margins in Canada than in the United States, the reverse of what we find in the baseline without reference pricing.[21]

[21] The left graph of Figure 5.5 shows that when weighting the distribution by the US quantities of each drug, a significant number of on-patent drugs will exhibit higher margins in Canada by an amount around 40% of the price of the drug. The right graph of Figure 5.5 shows that the share of drugs with substantially higher Canadian margins is amplified when weighting by Canadian quantities.

Figure 5.5: *Current and Counterfactual Margins Differences for on Patent Drugs*

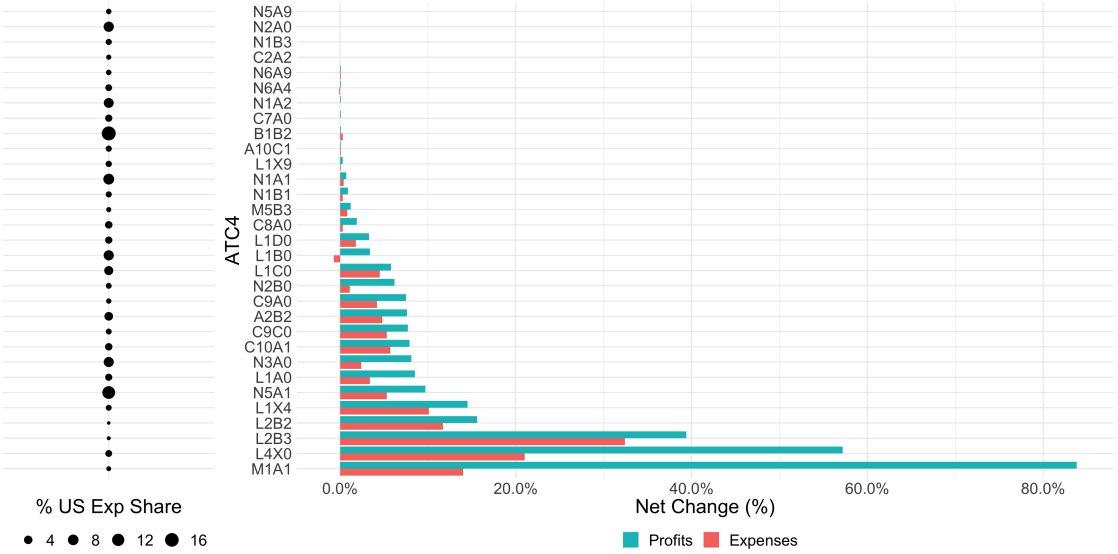


Note: The empirical distribution of the difference between margins in Canada and the US, $(p^{CA} - c^{CA}) - (p^{US} - c^{US})$, normalized by each drug's US price and weighted by the quantity of the drug sold in the US (left) and in Canada (right). The dotted distribution is the counterfactual while the solid one is the estimated current distribution.

These graphs show that if the status quo margins are larger in the US, such that the distribution of differences is largely on the positive, then international reference pricing will not make the distribution of differences centered on zero. Rather, margins will be higher in Canada for a substantial quantity of on-patent drugs. This occurs despite the fact that prices become close because marginal costs are typically higher in the US than in Canada. That is, international reference pricing policy makes prices more equal across countries but makes margins lower in the US and thus makes the US contribute less than Canada to pharmaceutical profits by unit of consumption.

Finally, figure 5.6 shows the net effect of imposing international reference pricing on global (that is, the US and Canada combined) expenses, profits and welfare. Overall, total expenses in the US and Canada increase by 2.7%, total profits increase by 5.1% and consumer welfare decreases by 1%. Most of the changes occur in Canada, whose scale is much smaller than the US. However, the price increases in Canada are so large that on net expenses increase and net welfare decreases. In summary, an international reference pricing policy in the US has globally negative effects on the referenced country, but is not able to substantially decrease either prices or expenses on drugs in the US. Detailed results are presented in Table 7.12 in appendix 7.5.1.

Figure 5.6: *Net Global Percent Changes in Expenses, Profits and Welfare from Reference Pricing*



Note: Each bar represents the net percent change in global expenses (red), profits (green) and welfare (blue) in each ATC-4 that results from moving from the baseline without reference pricing to our main counterfactual. For scale, on the left, we present the percent of baseline US expenditures that each ATC-4 represents.

5.1.2 Variations on Market Size and MFN Rule

As demonstrated in our counterfactual simulations, the international reference pricing policy is likely to have small effects in most ATC-4 classes in the US, with a few notable exceptions. However, it would have generally very large effects in the reference country—in our case, Canada. Our simulation results show that, in general, it would be too costly for pharmaceutical firms to decrease prices in the US. Rather, firms would respond to the policy by increasing prices in Canada—even if regulations in Canada can impose some downward pressure on price-setting in Canada. In the 31 ATC-4 classes of drugs, total spending in Canada is $472 million on average annually, while it is $ 6,946 million in the US. This difference is explained by both the fact that prices are much higher in the US than in Canada, and also because Canada is a much smaller country than the US in population.

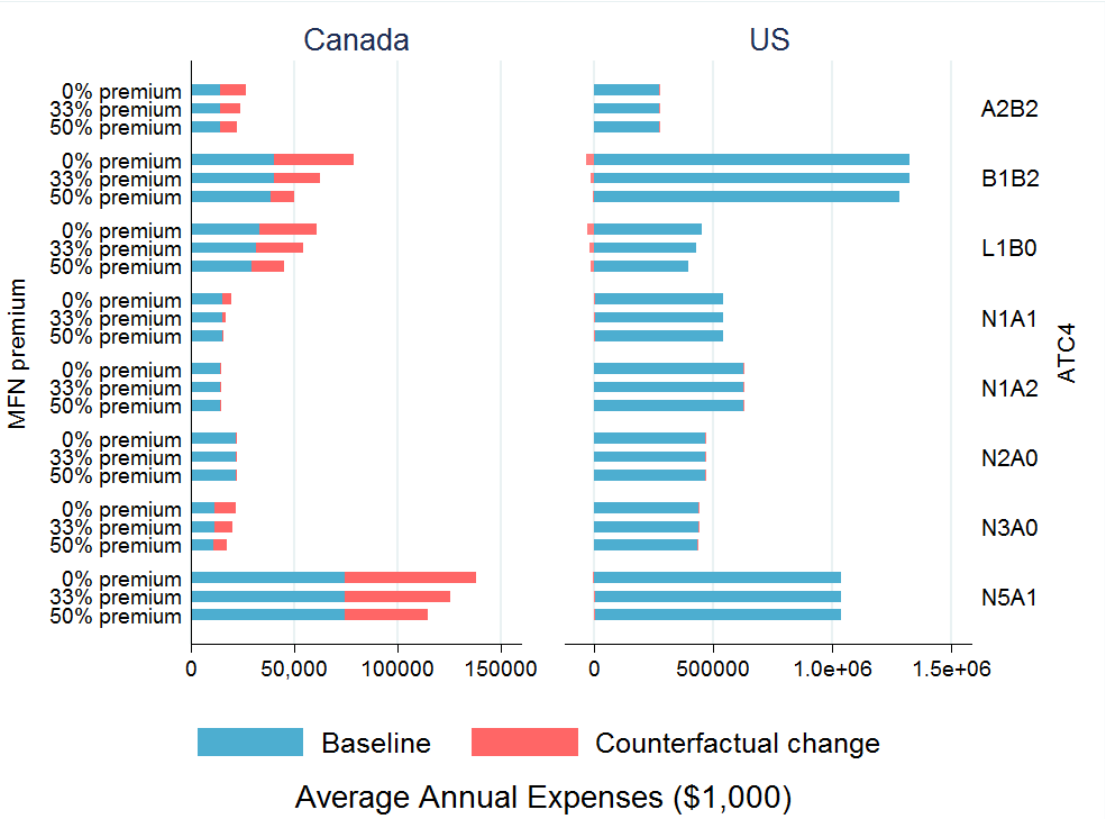
Given these results, we investigate several variants of the international reference pricing. The first variant that we consider is a Most Favored Nation clause in which the United States allows pharmaceutical companies to set prices in the US so long as the price in the United States does not exceed a maximum allowed premium above the price in Canada. In other words, in order for an on-patent drug to be sold in the United States, it must be that:

$$p_j^{US} \leq (1+\eta) p_j^{CA}, \tag{5.6}$$

where η is the maximum allowable premium. Given that Canadian prices are typically lower than in the US, we consider premiums set at 33% and 50%.[22] A policy of this sort would be a priori less stringent on price-setting in the US and Canada, and could result in smaller price changes than when the allowed premium is 0%.

The second policy variant that we consider is reference pricing with respect to a different country, especially one with a larger market. To approximate the implications of referencing a larger country without re-estimating our model for other countries, we simulate the international reference pricing policy in our main counterfactual section with a scaled up market size for Canada, such that it represents half of the US market, or is of the same size as the US market.

Figure 5.7: *Counterfactual Expenses Changes in Large ATC-4s with Varying MFN rule (0, +33%, +50%)*



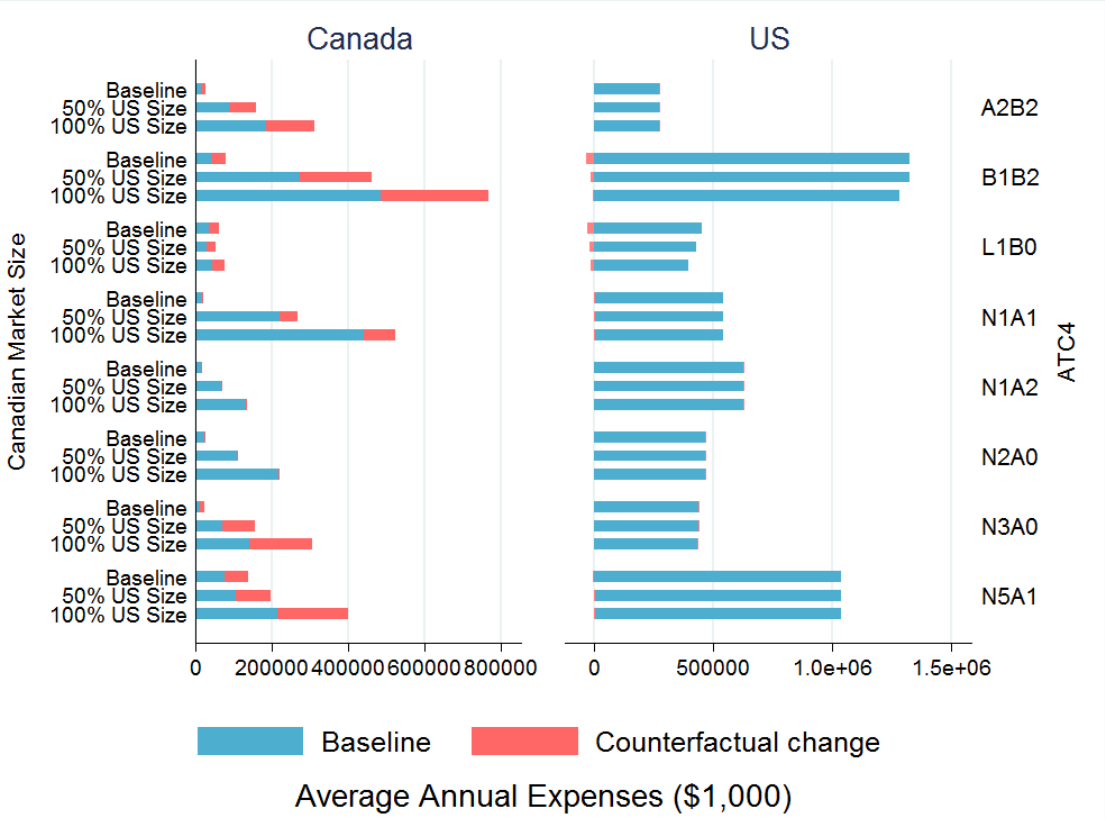
Note: Each blue bar indicates the average annual expenditure in each ATC-4 class in the baseline without reference pricing. The red bar indicates the change in average annual expenditure resulting from imposing reference pricing. A red bar to the right of the blue bar indicates that expenditure increased by the length of the red bar. A red bar to the left of the blue bar indicates that expenditure decreased by the length of the red bar.

Figures 5.7 and 5.8 show the results of these counterfactual simulations for a subset of ATC-4 classes that each represent more than 3% of pharmaceutical expenditures in the US. Table 7.13

[22] While we only examine weakly positive η, many settings with most favored nation contracts involve negative η. Such contracts guarantee the referencing country (or firm) a better price than others by at least a fixed percentage. These contracts are often referred to as "MFN-plus" contracts.

in Appendix 7.5.1 presents the detailed results. We present the counterfactual expenses in the benchmark case (e.g. referencing Canadian prices), as well as for simulations with marked-up reference pricing (but keeping the Canadian market as is), and simulations with an inflated Canadian reference market (but the baseline reference pricing rule).

Figure 5.8: *Counterfactual Expenses Changes in Large ATC-4s with a Larger Reference Market*



Note: Each blue bar indicates the average annual expenditure in each ATC-4 class in the baseline without reference pricing. The red bar indicates the change in average annual expenditure resulting from imposing reference pricing. A red bar to the right of the blue bar indicates that expenditure increased by the length of the red bar. A red bar to the left of the blue bar indicates that expenditure decreased by the length of the red bar. There is some variation in convergence for different US sizes.

We find that allowing for a +33% or +50% markup on reference prices in the US would lead to smaller price increases in Canada as well as similarly small changes in expenses in the US. Again, the simulations demonstrate that when the reference country's market size is relatively small, the reference pricing policy would mostly affect the referenced country, without benefiting the US to a large degree. Our results show that increasing the market size of the referenced country to be comparable to the US—half of or comparable to the US market—implies greater reduction in the US price and a smaller increase in the Canadian price. In the ATC-4 class B1B2, which covers fractionated heparins (an anticoagulant), for instance, US expenses decrease by 13% and 21% when referencing a Canadian market that is scaled up to be half the size of the US market, and the same size as the US respectively. This suggests that reference pricing

may be more effective when referencing larger countries. Nonetheless, expenses in the US do not decrease substantially across ATC-4s, and the large asymmetry in effect size between the US and Canada remains because margins can stay larger in the US than in Canada because of the bargaining over prices in Canada.

5.2 Alternative Implementation of International Reference Pricing

5.2.1 Price Floor

In this section, we simulate the impacts of a reference pricing counterfactual in which the pharmaceutical company is able to commit to a price p_j^{US} in the United States prior to negotiating a price p_j^{CA} with the Canadian regulator. The firm's chosen United States price behaves effectively as a price floor in negotiations with Canada: if the negotiated rate in Canada is lower than the price floor, then the firm is forced to exit the United States market. Negotiations between the pharmaceutical company and the Canadian regulator take this into account so that the firm's agreement surplus in Canada is:

$$\begin{aligned}\Delta\Pi_j(p_j^{CA}, p_j^{US}, \mathbf{p}_{-j}^{CA}, \mathbf{p}_{-j}^{US}) \equiv & \underbrace{\Pi_j^{US}(p_j^{US}, \mathbf{p}_{-j}^{US})\mathbf{1}_{\{p_j^{CA} \geq p_j^{US}\}} + \Pi_j^{CA}(p_j^{CA}, \mathbf{p}_{-j}^{CA})}_{\text{total profit of } j \text{ if agrees in CA}} \\ & - \underbrace{\Pi_j^{US}(p_j^{US}, \mathbf{p}_{-j}^{US})}_{\text{profit of } j \text{ if only in the US}} ,\end{aligned} \tag{5.7}$$

and the negotiated rate is:

$$p_j^{CA}(p_j^{US}, \mathbf{p}_{-j}^{CA}, \mathbf{p}_{-j}^{US}) \equiv \arg\max_p \left(\underbrace{\Delta\Pi_j(p, p_j^{US}, \mathbf{p}_{-j}^{CA}, \mathbf{p}_{-j}^{US})}_{\text{profit gain from agreement}} \right)^{\rho_j} \left(\underbrace{\Delta_j W_{CA}(p, \mathbf{p}_{-j}^{CA})}_{\text{welfare gain in CA from agreement}} \right)^{1-\rho_j} . \tag{5.8}$$

Strategic pharmaceutical companies will account for the correspondence in (5.8) and set their price in the United States to maximize their global profit:[23]

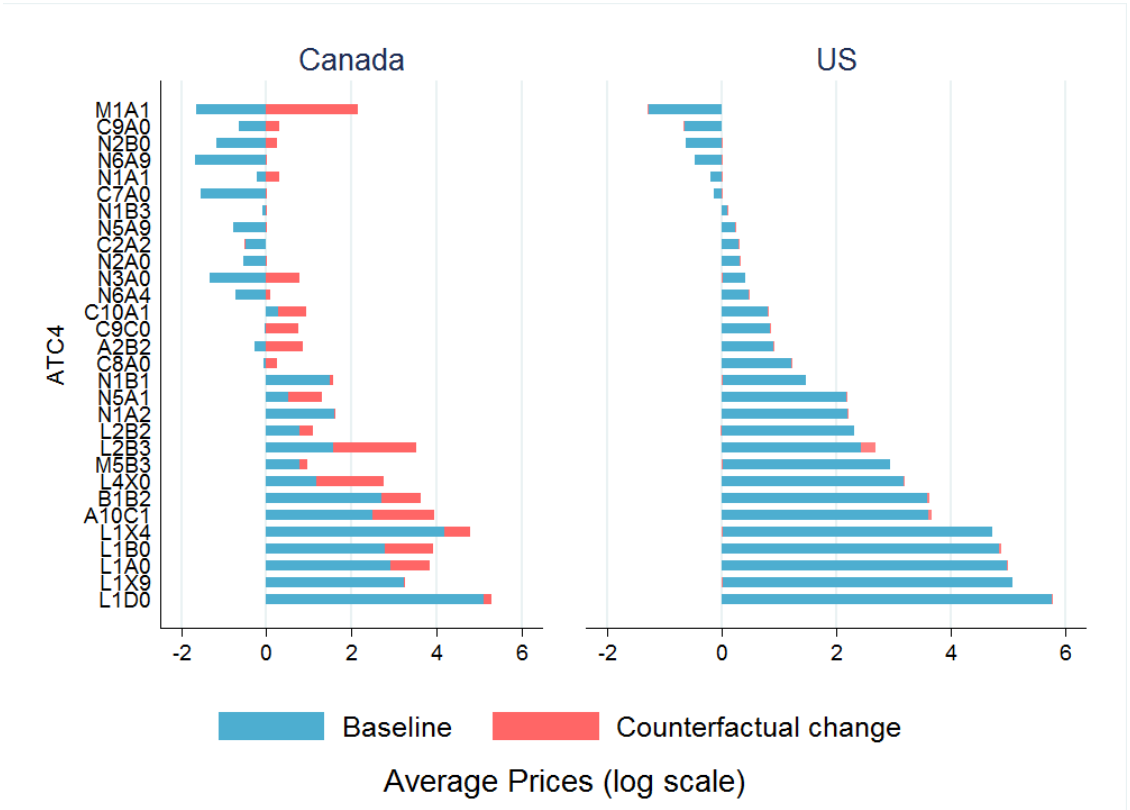
$$p_j^{US}(\mathbf{p}_{-j}^{CA}, \mathbf{p}_{-j}^{US}) \equiv \arg\max_p \quad \Pi_j^{US}\left(p, \mathbf{p}_{-j}^{US}\right) + \Pi_j^{CA}(p_j^{CA}(p, \mathbf{p}_{-j}^{CA}, \mathbf{p}_{-j}^{US}), \mathbf{p}_{-j}^{CA}) \tag{5.9}$$

[23] It is also possible that the firm prefers to exit the United States market. We additionally allow the firm to exit the United States when the profit from unrestricted sales in Canada exceed the firm's maximum global profit when serving both markets under the reference pricing rule.

In equilibrium, the prices $\{(p_j^{US*}, p_j^{CA*})\}_j$ will satisfy (5.8) and (5.9) for each j:

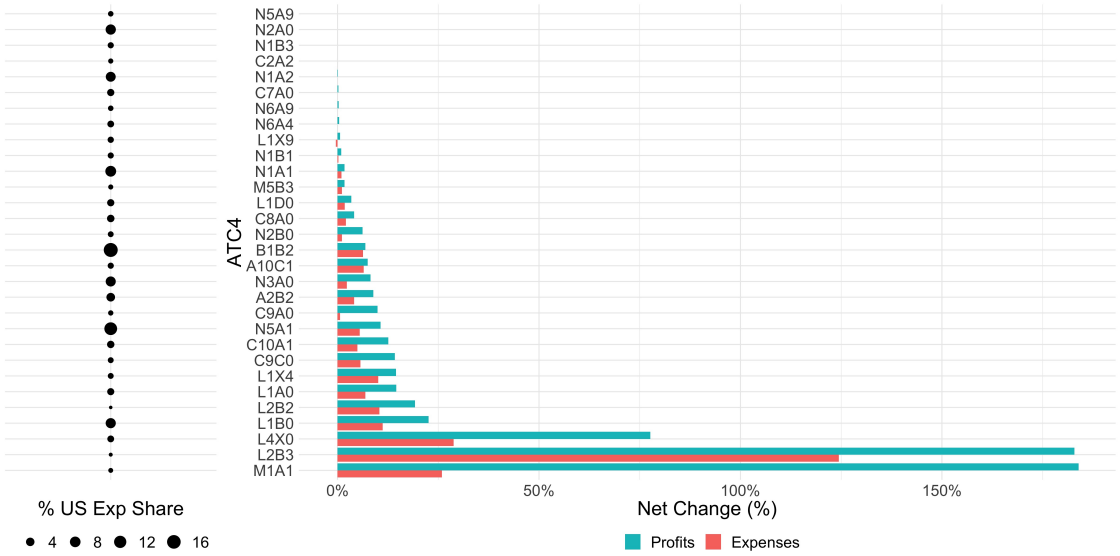
$$\begin{aligned} p_j^{US*} &= p_j^{US}(\mathbf{p}_{-j}^{CA*}, \mathbf{p}_{-j}^{US*}), \\ p_j^{CA*} &= p_j^{CA}(p_j^{US*}, \mathbf{p}_{-j}^{CA*}, \mathbf{p}_{-j}^{US*}). \end{aligned} \tag{5.10}$$

Figure 5.9: *Counterfactual Prices with US as Price Floor in Canada*



Note: Each blue bar indicates the log of average prices in each ATC-4 class in the baseline without reference pricing. The red bar indicates the change in log average prices resulting from imposing reference pricing. A red bar to the right of the blue bar indicates that prices increased by the length of the red bar. A red bar to the left of the blue bar indicates that prices decreased by the length of the red bar.

Figure 5.10: *Net Global Percent Changes in Expenses, Profits and Welfare from Reference Pricing with US as Price Floor for Canada*



Note: Each bar represents the net percent change in global expenses (red), profits (green) and welfare (blue) in each ATC-4 that results from moving from the baseline without reference pricing to our main counterfactual. For scale, on the left, we present the percent of baseline US expenditures that each ATC-4 represents.

Using our model estimates, we simulate the impact of such a reference pricing rule in which the pharmaceutical company first commits to a price in the United States and then negotiates a price in Canada. We show some of the findings from these simulations in Figures 5.9 and 5.10. Additional figures and tables can be found in Appendix 7.5.2. As in our previous counterfactuals, Figure 5.9 indicates that prices increase in Canada. However, unlike in the previous counterfactuals, it is sometimes the case that prices in the United States increase. Intuitively, this is because the profit maximizing price in Canada may be higher than in the United States. This incentivizes facilities to raise the price in the United States in order to create a price floor in Canada that moves the negotiated rate in Canada closer to the profit maximizing price in Canada. Comparing Figure 5.10 to Figure 5.6 shows that allowing firms to commit to a price in the United States leads to changes in global expenditure, profits, and welfare that are larger in magnitude (5.3%, 11.7%, and -1.5% versus 2.7%, 5.1%, and -1.0% without commitment).

5.2.2 International Reference Pricing with respect to a Price Index

6 Conclusion

We employ detailed quantity and price data from IMS Health in our analysis to estimate a random coefficients logit demand model with a structural quality metric for each drug. Under the assumption that prices are set according to Nash bargaining between the country and firm

(Horn and Wolinsky, 1988; Crawford and Yurukoglu, 2012; Grennan, 2013; Gowrisankaran et al., 2015) in a regulated price country such as Canada, we are able to separately identify costs and bargaining parameters. Since Nash bargaining involves maximizing the weighted log-sum of both parties' transaction utility, we can interpret the bargaining parameters as the degree to which countries' policymakers choose to trade off between firm profits and immediate consumer welfare. We then perform counterfactual simulations of a most favored nation policy in the US involving international reference pricing constraints from other markets.

In the main specification, an international reference pricing policy where the price in the US cannot be higher than in Canada amounts to having Canadian prices as price ceilings for the same drugs sold in the US when firms negotiate prices with the regulator in Canada.

We find that such policy would decrease prices slightly in the US but increase them dramatically in Canada because firms will internalize the across-country restrictions involved by the US reference pricing. We find that expenses on pharmaceuticals would increase considerably in Canada but not change significantly in the US. When comparing margins of on-patent drugs present in Canada and the US, we find that while the distribution of margins differences between the US and Canada is currently skewed towards higher margins in the US, the international reference pricing policy would skew this difference towards higher margins in Canada, while prices would be close because the US would not pay over Canada for its higher marginal costs. The effects on profit and welfare show that profits of firms would increase significantly in Canada while consumer welfare would decrease, and the effects in the US remain small. Overall, we find modest consumer welfare gains in the US, but substantial consumer welfare losses in Canada. Moreover, we find that pharmaceutical profits increase in net, suggesting that reference pricing of this form would constitute a net transfer from consumers to firms. Some variants of the simulations show that one would need a much larger reference market for this policy to have significant price reduction effects in the US.

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7 Appendix

7.1 Descriptive Statistics

Table 7.1: *Average Prices in the US and Canada*

		All		Patented		Branded Off		Generic	
ATC4		CA	US	CA	US	CA	US	CA	US
A10C1	H INSUL+ANG FAST ACT	12.05	37.13	12.05	37.13	0.00	0.00	0.00	0.00
A2B2	ACID PUMP INHIBITORS	0.76	2.44	0.83	2.75	0.67	3.43	0.59	0.63
B1B2	FRACTIONATED HEPARINS	15.65	37.61	15.65	38.01	0.00	30.42	0.00	28.47
C10A1	STATINS (HMG-COA RED	1.32	2.23	1.77	3.43	1.99	2.32	0.49	0.50
C2A2	ANTIHYPER.PL MAINLY PERI	0.60	1.35	46.08	13.16	2.79	2.09	0.16	1.06
C7A0	B-BLOCKING AGENTS,PLAIN	0.22	0.87	0.30	3.37	1.11	2.14	0.18	0.60
C8A0	CALCIUM ANTAGONIST PLAIN	0.93	3.40	1.30	2.32	0.83	25.38	0.49	1.17
C9A0	ACE INHIBITORS PLAIN	0.52	0.51	0.68	1.68	0.51	1.70	0.26	0.30
C9C0	ANGIOTEN-II ANTAG, PLAIN	0.97	2.31	1.10	2.72	1.19	2.64	0.25	0.47
L1A0	ALKYLATING AGENTS	17.69	135.17	24.69	229.55	1.53	109.79	14.51	48.55
L1B0	ANTIMETABOLITES	16.27	124.41	18.00	382.37	17.90	209.39	11.15	17.12
L1C0	VINCA ALKALOIDS	270.87	443.02	468.30	999.85	110.03	350.44	86.50	73.89
L1D0	ANTINEOPLAS. ANTIBIOTICS	164.08	322.95	250.68	1350.26	360.70	998.83	77.61	108.92
L1X4	A-NEO PROTEIN KINASE INH	66.23	112.85	66.35	112.77	65.16	0.00	25.55	146.05
L1X9	ALL OTH. ANTINEOPLASTICS	20.64	138.60	642.79	741.55	0.94	0.00	1.64	15.12
L2B2	CYTO ANTI-ANDROGENS	2.19	10.08	10.43	30.28	1.45	9.63	0.69	1.31
L2B3	CYTOSTAT AROMATASE INHIB	4.81	11.29	4.88	11.75	3.80	17.52	2.23	0.52
L4X0	OTHER IMMUNOSUPPRESSANTS	3.07	23.46	3.01	18.79	0.75	5.92	5.29	59.29
M1A1	ANTIRHEUMATICS NON-S PLN	0.19	0.27	0.67	3.68	0.50	0.95	0.13	0.23
M5B3	BISPHOSPH OSTEOPOROSIS	2.11	18.17	2.43	27.81	3.21	19.98	1.40	2.49
N1A1	INHAL GEN ANAESTHETICS	0.81	0.82	0.79	0.92	0.92	0.76	0.26	0.54
N1A2	INJECT GEN ANAESTHETICS	5.00	9.03	11.73	76.79	5.43	18.96	4.53	5.96
N1B1	ANAESTH LOCAL MEDIC INJ	4.48	4.35	10.97	15.64	4.63	6.76	3.19	2.84
N1B3	ANAESTH LOCAL TOPICAL	0.92	1.11	6.68	23.42	1.04	3.90	0.39	0.85
N2A0	NARCOTIC ANALGESICS	0.59	1.36	0.77	3.20	1.18	3.86	0.48	1.14
N2B0	NON-NARCOTIC ANALGESICS	0.31	0.53	0.56	14.59	0.34	1.34	0.30	0.39
N3A0	ANTI-EPILEPTICS	0.26	1.49	1.36	4.30	0.20	5.65	0.20	0.79
N5A1	ATYPICAL ANTIPSYCHOTICS	1.77	9.09	1.82	10.36	3.09	4.92	0.43	3.43
N5A9	CONVNTL ANTIPSYCHOTICS	0.46	1.27	2.90	2.76	1.17	16.30	0.25	1.11
N6A4	SSRI ANTIDEPRESSANTS	0.48	1.61	1.35	3.61	1.44	4.22	0.28	0.48
N6A9	ANTIDEPRESSANTS ALL OTH	0.19	0.63	0.40	2.95	0.58	3.47	0.13	0.32

Note: Average price by ATC-4, country, in US$ per std. unit.

7.2 Market Size Approximation

7.2.1 Method

We use Huang and Rojas (2013, 2014) to calibrate the potential market size using a simpler logit demand model. With a logit specification, we have:

$$\ln q_{jt} - \ln q_{0mt} = \alpha_{m(j)} \ln p_{jt} + \beta_{m(j)} g_j + \lambda_{m(j)} x_{jt} + \phi_j + \mu_{m(j)t} + \xi_{jt}$$

with $M_{mt} = q_{0t} + \sum_{j=1}^{J_m} q_{jt}$.

As q_{0mt} or M_{mt} are not observed, we can use the difference across inside goods to identify some of the parameters of the model:

$$\ln q_{jt} - \ln q_{j't} = \alpha_{m(j)} (\ln p_{jt} - \ln p_{j't}) + \beta_{m(j)} (g_j - g_{j'}) + (\phi_j - \phi_{j'}) + (\xi_{jt} - \xi_{j't})$$

which does not depend on unobserved q_{0mt} or M_{mt} in order to identify α_m and β_m that are denoted $\hat{\alpha}_m$, $\hat{\beta}_m$ from these last specifications. For a given M_{mt} we have

$$\ln q_{jt} - \ln \left(M_{mt} - \sum_{j=1}^{J_m} q_{jt} \right) = \alpha_m \ln p_{jt} + \beta_m g_j + \lambda_m x_{jt} + \phi_j + \mu_{mt} + \xi_{jt}$$

whose estimation with two stage least squares using the same instruments as with our BLP demand model leads to the estimates $\hat{\alpha}_m (M_{mt})$, $\hat{\beta}_m (M_{mt})$, $\hat{\lambda}_m (M_{mt})$.

Then, we look for M_{mt} that solves the following minimization problem:

$$\min_{M_{mt} \geq \sum_{j=1}^{J_m} q_{jt}} \sum_{t=1}^{T} \left(\hat{\alpha}_m (M_{mt}) - \hat{\alpha}_m \right)^2 + \left(\hat{\beta}_m (M_t) - \hat{\beta}_m \right)^2 + \left(\hat{\lambda}_m (M_t) - \hat{\lambda}_m \right)^2$$

7.2.2 Estimates

7.3 Supply sides estimates

Table 7.2: *Outside Good Market Share Estimates by country and ATC-4*

		s_{0mt}	
ATC4		US	Canada
A10C1	H INSUL+ANG FAST ACT	0.11	0.34
A2B2	ACID PUMP INHIBITORS	0.44	0.19
B1B2	FRACTIONATED HEPARINS	0.09	0.10
C10A1	STATINS (HMG-COA RED	0.27	0.10
C2A2	ANTIHYPER.PL MAINLY PERI	0.31	0.21
C7A0	B-BLOCKING AGENTS,PLAIN	0.10	0.25
C8A0	CALCIUM ANTAGONIST PLAIN	0.18	0.09
C9A0	ACE INHIBITORS PLAIN	0.65	0.60
C9C0	ANGIOTEN-II ANTAG, PLAIN	0.44	0.10
L1A0	ALKYLATING AGENTS	0.11	0.17
L1B0	ANTIMETABOLITES	0.13	0.27
L1C0	VINCA ALKALOIDS	0.59	0.39
L1D0	ANTINEOPLAS. ANTIBIOTICS	0.09	0.21
L1X4	A-NEO PROTEIN KINASE INH	0.17	0.54
L1X9	ALL OTH. ANTINEOPLASTICS	0.14	0.14
L2B2	CYTO ANTI-ANDROGENS	0.46	0.12
L2B3	CYTOSTAT AROMATASE INHIB	0.35	0.17
L4X0	OTHER IMMUNOSUPPRESSANTS	0.47	0.20
M1A1	ANTIRHEUMATICS NON-S PLN	0.12	0.14
M5B3	BISPHOSPH OSTEOPOROSIS	0.17	0.44
N1A1	INHAL GEN ANAESTHETICS	0.10	0.27
N1A2	INJECT GEN ANAESTHETICS	0.11	0.66
N1B1	ANAESTH LOCAL MEDIC INJ	0.10	0.26
N1B3	ANAESTH LOCAL TOPICAL	0.84	0.51
N2A0	NARCOTIC ANALGESICS	0.22	0.18
N2B0	NON-NARCOTIC ANALGESICS	0.09	0.09
N3A0	ANTI-EPILEPTICS	0.48	0.12
N5A1	ATYPICAL ANTIPSYCHOTICS	0.18	0.14
N5A9	CONVNTL ANTIPSYCHOTICS	0.19	0.63
N6A4	SSRI ANTIDEPRESSANTS	0.11	0.92
N6A9	ANTIDEPRESSANTS ALL OTH	0.21	0.39

Note: Estimated outside good market shares obtained form the market size estimates by ATC-4 , country and quarter. Table presents average across quarters.

Table 7.3: *Margins Estimates by ATC-4*

Margins		Canada				US		
ATC4	Label	All	On Patent	Branded Off Patent	Generics	All	On Patent	Branded Off Patent
A10C1	H INSUL+ANG FAST ACT	18.46	18.46			85.71	85.71	
A2B2	ACID PUMP INHIBITORS	37.81	38.58	28.47	83.87	54.04	53.87	63.67
B1B2	FRACTIONATED HEPARINS	38.61	40.25	0.00	0.00	96.56	96.95	100.00
C10A1	STATINS (HMG-COA RED	60.64	59.13	43.99	82.24	54.01	58.66	62.88
C2A2	ANTIHYPER.PL MAINLY PERI	49.10	96.35	96.62	16.52	11.30	37.65	11.83
C7A0	B-BLOCKING AGENTS,PLAIN	19.68	4.64	16.35	25.92	19.62	48.86	47.56
C8A0	CALCIUM ANTAGONIST PLAIN	25.12	73.56	10.69	21.73	39.46	66.31	45.52
C9A0	ACE INHIBITORS PLAIN	62.75	46.83	93.93	36.20	20.56	23.31	29.53
C9C0	ANGIOTEN-II ANTAG, PLAIN	47.54	44.63	96.05	43.82	51.47	53.49	10.64
L1A0	ALKYLATING AGENTS	11.69	13.03	1.41	10.95	39.69	47.46	46.62
L1B0	ANTIMETABOLITES	8.10	6.93	5.70	19.50	42.26	46.80	45.23
L1C0	VINCA ALKALOIDS	50.78	45.88	50.09	88.92	42.84	47.19	37.88
L1D0	ANTINEOPLAS. ANTIBIOTICS	31.08	45.37	20.93	25.08	35.24	46.35	49.96
L1X4	A-NEO PROTEIN KINASE INH	32.23	31.83	55.66	3.73	52.71	52.90	0.00
L1X9	ALL OTH. ANTINEOPLASTICS	13.40	14.06	76.78	3.61	42.34	46.55	0.00
L2B2	CYTO ANTI-ANDROGENS	35.18	29.57	50.79	77.99	49.43	54.39	48.54
L2B3	CYTOSTAT AROMATASE INHIB	50.67	50.58	29.19	73.32	63.92	64.26	47.59
L4X0	OTHER IMMUNOSUPPRESSANTS	19.66	33.59	0.65	2.73	28.20	47.87	48.10
M1A1	ANTIRHEUMATICS NON-S PLN	55.06	42.59	88.46	47.57	9.52	25.50	45.53
M5B3	BISPHOSPH OSTEOPOROSIS	6.78	4.27	17.31	27.39	57.62	62.06	48.38
N1A1	INHAL GEN ANAESTHETICS	62.35	41.64	94.54	17.15	64.71	73.89	45.85
N1A2	INJECT GEN ANAESTHETICS	20.27	13.40	16.56	24.06	25.12	47.01	58.07
N1B1	ANAESTH LOCAL MEDIC INJ	79.76	67.59	99.11	63.82	23.45	51.97	24.55
N1B3	ANAESTH LOCAL TOPICAL	68.36	47.28	71.38	28.14	5.34	1.82	6.54
N2A0	NARCOTIC ANALGESICS	40.15	49.76	47.88	37.55	10.30	11.35	46.03
N2B0	NON-NARCOTIC ANALGESICS	56.38	6.47	93.59	70.32	13.78	46.96	43.05
N3A0	ANTI-EPILEPTICS	29.69	20.77	23.32	40.51	25.82	45.45	44.93
N5A1	ATYPICAL ANTIPSYCHOTICS	18.67	9.06	92.70	20.99	50.42	53.94	4.12
N5A9	CONVNTL ANTIPSYCHOTICS	12.59	60.06	15.83	8.27	6.64	18.12	45.48
N6A4	SSRI ANTIDEPRESSANTS	2.35	1.37	2.15	6.29	46.86	58.64	47.95
N6A9	ANTIDEPRESSANTS ALL OTH	18.77	12.00	9.91	28.85	27.27	48.15	50.76

Note: Average margins in percentage of US average price by ATC-4 across all quarters. Average across drugs within category is weighted by market share. For generics in the US we impose price equal to marginal costs and do not estimate margins but they are taken into account in the average margin for all drugs in the US.

Table 7.4: *Estimates of ρ_{jm} by ATC-4*

ATC4		On Patent	Branded Off	Generic
A10C1	H INSUL+ANG FAST ACT	0.62		
A2B2	ACID PUMP INHIBITORS	0.55	0.90	0.87
B1B2	FRACTIONATED HEPARINS	0.70		
C10A1	STATINS (HMG-COA RED	0.54	1.00	0.77
C2A2	ANTIHYPER.PL MAINLY PERI	1.00	1.00	0.94
C7A0	B-BLOCKING AGENTS,PLAIN	0.72	1.00	1.00
C8A0	CALCIUM ANTAGONIST PLAIN	0.56	0.89	0.86
C9A0	ACE INHIBITORS PLAIN	0.47	0.95	1.00
C9C0	ANGIOTEN-II ANTAG, PLAIN	0.60	0.94	0.50
L1A0	ALKYLATING AGENTS	0.91	0.50	1.00
L1B0	ANTIMETABOLITES	0.64	0.50	1.00
L1C0	VINCA ALKALOIDS	0.50	0.50	0.98
L1D0	ANTINEOPLAS. ANTIBIOTICS	0.99	0.50	0.50
L1X4	A-NEO PROTEIN KINASE INH	1.00	0.50	0.50
L1X9	ALL OTH. ANTINEOPLASTICS	0.92	0.50	0.57
L2B2	CYTO ANTI-ANDROGENS	0.83	0.94	0.61
L2B3	CYTOSTAT AROMATASE INHIB	0.70	0.79	0.58
L4X0	OTHER IMMUNOSUPPRESSANTS	0.95	0.91	1.00
M1A1	ANTIRHEUMATICS NON-S PLN	0.44	0.91	1.00
M5B3	BISPHOSPH OSTEOPOROSIS	0.93	0.95	0.54
N1A1	INHAL GEN ANAESTHETICS	0.45	0.57	1.00
N1A2	INJECT GEN ANAESTHETICS	1.00	1.00	0.92
N1B1	ANAESTH LOCAL MEDIC INJ	0.96	1.00	0.75
N1B3	ANAESTH LOCAL TOPICAL	0.50	0.50	0.58
N2A0	NARCOTIC ANALGESICS	0.51	0.78	0.89
N2B0	NON-NARCOTIC ANALGESICS	0.50	0.96	0.88
N3A0	ANTI-EPILEPTICS	0.87	0.93	1.00
N5A1	ATYPICAL ANTIPSYCHOTICS	0.86	0.86	0.94
N5A9	CONVNTL ANTIPSYCHOTICS	0.64	0.97	0.94
N6A4	SSRI ANTIDEPRESSANTS	0.80	0.99	0.91
N6A9	ANTIDEPRESSANTS ALL OTH	0.27	0.89	0.99

7.4 Theoretical Results

This section is meant to show that an international reference pricing policy can only increase price in the referenced country and decrease it in the referencing country. We show it under "regularity" conditions of the profit function and conditions where the same drugs are present in the referencing and referenced country. We start by showing it when we have a monopoly drug in each country, then when we have a duopoly.

7.4.1 Monopoly case

Let's start with monopoly firms in each country A and B.

Consider one firm producing a product, at marginal costs c. Denote $D_A(p_A)$ and $D_B(p_B)$ the demands in countries A and B, respectively, when their prices are p_A and p_B. We assume that each profit function $\Pi_A(p_A) \equiv (p_A - c) D_A(p_A)$ and $\Pi_B(p_B) \equiv (p_B - c) D_B(p_B)$ is strictly concave in price and have a finite maximum above marginal cost.

Under regulation, we suppose that a governmental agency negotiates price by engaging in Nash bargaining with the firm. The governmental's objective function takes the general form $W(p_B)$ in country B, where $W(.)$ is decreasing over $[c, +\infty)$. For instance, $W(p_B)$ could be consumer surplus, social welfare or coverage.

Thus, the unregulated price in country A solves

$$p_A^* = \underset{c \leq p_A}{\arg\max} \Pi_A(p_A)$$

and the price in country B under regulation solves the following maximization program:

$$p_B^* = \underset{p_B \geq c}{\arg\max} \Pi_B(p_B)^{1-\rho} \Delta W(p_B)^{\rho}$$

where $\Delta W(p_B) \equiv W(p_B) - W(\infty)$ is decreasing in p_B and $\rho \in (0, 1]$ captures the bargaining power of the governmental agency.

Now with international reference pricing imposing that the firm can sell in country A only if $p_A \leq p_B$, the new price equilibrium (p_A^{**}, p_B^{**}) simultaneously solves:

$$\begin{cases} p_A^{**} = \tilde{p}_A(p_B^{**}) \equiv \underset{c \leq p_A \leq p_B^{**}}{\arg\max} \Pi_A(p_A) \\ p_B^{**} = \underset{p_B \geq c}{\arg\max} \left[\Pi_A(\tilde{p}_A(p_B)) + \Pi_B(p_B) - \Pi_A(p_A^*)\right]^{1-\rho} \Delta W(p_B)^{\rho} \end{cases}$$

where $\Pi_A(\tilde{p}_A(p_B)) + \Pi_B(p_B)$ is the firm profit in A and B if selling if both countries and $\Pi_A(p_A^*)$ is the firm profit in A only if disagreeing with B.

Proposition The international reference pricing policy implies that the price in country A decreases and the price in country B increases:

$$p_A^{**} \leq p_A^* \quad \text{and} \quad p_B^{**} \geq p_B^*$$

Proof *Let's start with proving that* $p_A^{**} \leq p_A^*$*:*

From its definition, $p_A^{**} \equiv \tilde{p}_A(p_B^{**}) = p_A^*$ if $p_A^* \leq p_B^{**}$. If $p_A^* > p_B^{**}$, then $p_A^{**} \equiv \tilde{p}_A(p_B^{**}) \leq p_B^{**}$ because $\tilde{p}_A(p) \leq p$ for all p and thus $p_A^{**} < p_A^*$. This proves that in all cases $p_A^{**} \leq p_A^*$.

Let's prove now that $p_B^{**} \geq p_B^*$*:*

Let's define

$$\Delta\Pi_A\left(p_A^*, p_B\right)) \equiv \Pi_A\left(\tilde{p}_A(p_B)\right) - \Pi_A\left(p_A^*\right)$$

$\Delta\Pi_A\left(p_A^*, p_B\right))$ is negative increasing in p_B and equal to zero when $p_B \geq p_A^*$:
It is negative because $p_A^* = \underset{p_A \geq c}{\arg\max} \Pi_A\left(p_A\right)$ and thus $\Pi_A\left(\tilde{p}_A(p_B)\right) \leq \Pi_A\left(p_A^*\right)$. By concavity of $\Pi_A\left(.\right)$, it is increasing on $[0, p_A^*[$, $\tilde{p}_A(p_B)$ is also weakly increasing in p_B, thus $\Pi_A\left(\tilde{p}_A(p_B)\right)$ is increasing in p_B because $\tilde{p}_A(p_B) \leq \tilde{p}_A(p_A^*) \leq p_A^*$.

Then, using $p_B^{**} = \underset{p_B \geq c}{\arg\max} \left[\Pi_B\left(p_B\right) + \Delta\Pi_A\left(p_A^*, p_B\right)\right] \Delta W\left(p_B\right)^{\frac{\rho}{1-\rho}}$ and $p_B^* = \underset{p_B \geq c}{\arg\max} \Pi_B\left(p_B\right) \Delta W\left(p_B\right)^{\frac{\rho}{1-\rho}}$, we have

$$\begin{aligned}
& \Pi_B\left(p_B^{**}\right) \Delta W\left(p_B^{**}\right)^{\frac{\rho}{1-\rho}} + \Delta\Pi_A\left(p_A^*, p_B^{**}\right) \Delta W\left(p_B^{**}\right)^{\frac{\rho}{1-\rho}} \\
= \; & \left[\Pi_B\left(p_B^{**}\right) + \Delta\Pi_A\left(p_A^*, p_B^{**}\right)\right] \Delta W\left(p_B^{**}\right)^{\frac{\rho}{1-\rho}} \\
\geq \; & \left[\Pi_B\left(p_B^*\right) + \Delta\Pi_A\left(p_A^*, p_B^*\right)\right] \Delta W\left(p_B^*\right)^{\frac{\rho}{1-\rho}} \text{ because of the definition of } p_B^{**} \\
= \; & \Pi_B\left(p_B^*\right) \Delta W\left(p_B^*\right)^{\frac{\rho}{1-\rho}} + \Delta\Pi_A\left(p_A^*, p_B^*\right) \Delta W\left(p_B^*\right)^{\frac{\rho}{1-\rho}} \\
\geq \; & \Pi_B\left(p_B^{**}\right) \Delta W\left(p_B^{**}\right)^{\frac{\rho}{1-\rho}} + \Delta\Pi_A\left(p_A^*, p_B^*\right) \Delta W\left(p_B^*\right)^{\frac{\rho}{1-\rho}} \text{ because of the definition of } p_B^*
\end{aligned}$$

Thus

$$\Delta\Pi_A\left(p_A^*, p_B^{**}\right) \Delta W\left(p_B^{**}\right)^{\frac{\rho}{1-\rho}} \geq \Delta\Pi_A\left(p_A^*, p_B^*\right) \Delta W\left(p_B^*\right)^{\frac{\rho}{1-\rho}}$$

If $p_B^* \geq p_B^{**}$ then $\Delta\Pi_A\left(p_A^*, p_B^*\right)) \Delta W\left(p_B^*\right)^{\frac{\rho}{1-\rho}} \geq \Delta\Pi_A\left(p_A^*, p_B^*\right)) \Delta W\left(p_B^{**}\right)^{\frac{\rho}{1-\rho}}$ because $\Delta\Pi_A\left(p_A^*, p_B^*\right)) \leq 0$ and $\Delta W\left(.\right)$ is positive decreasing. Using the above inequality, it implies

$$\Delta\Pi_A\left(p_A^*, p_B^{**}\right) \geq \Delta\Pi_A\left(p_A^*, p_B^*\right)$$

and thus $p_B^{**} \geq p_B^*$ because $\Delta\Pi_A\left(p_A^*, p_B\right)$ is increasing in p_B, which contradicts $p_B^* \geq p_B^{**}$ implying that it must be that $p_B^{**} \geq p_B^*$.

7.4.2 Duopoly case

Consider two firms competing against each other and producing two differentiated products, 1 and 2, at marginal costs c, respectively. Denote $D_{1c}\left(p_{1c}, p_{2c}\right)$ and $D_{2c}\left(p_{1c}, p_{2c}\right)$ as demands

for products 1 and 2 in country c, respectively, when their prices are given by p_{1c} and p_{2c}. We assume that each firm i's profit function $\Pi_{ic} \equiv (p_{ic} - c) D_{ic}(p_{ic}, p_{-ic})$ is strictly concave in its own price, weakly increasing in the rival's price, and that its best-response price is increasing in its rival's price (i.e., prices are strategic complements). We suppose further that a Nash equilibrium (p_{1c}^*, p_{2c}^*) to the Bertrand game exists and is unique.

Under regulation, we suppose that a governmental agency negotiates prices by engaging in simultaneous Nash bargaining with both firms. We assume that the governmental agency's objective function of country B takes the general form $W(p_{1B}, p_{2B})$, where $W(.,.)$ is decreasing over $[c, +\infty) \times [c, +\infty)$. For instance, $W(p_{1B}, p_{2B})$ could be consumer surplus, social welfare or coverage.

The prices that arise in country A solve the Bertrand-Nash equilibrium

$$\begin{cases} p_{1A}^* = \underset{p_{1A} \geq c}{\arg\max} \Pi_{1A}(p_{1A}, p_{2A}^*) \\ p_{2A}^* = \underset{p_{2A} \geq c}{\arg\max} \Pi_{2A}(p_{1A}^*, p_{2A}) \end{cases}$$

and in country B, the regulation solves the following system of maximization programs:

$$\begin{cases} p_{1B}^* = \underset{p_{1B} \geq c}{\arg\max} \Pi_{1B}(p_{1B}, p_{2B}^*)^{1-\rho_1} \Delta W_1(p_{1B}, p_{2B}^*)^{\rho_1} \\ p_{2B}^* = \underset{p_{2B} \geq c}{\arg\max} \Pi_{2B}(p_{1B}^*, p_{2B})^{1-\rho_2} \Delta W_2(p_{1B}^*, p_{2B})^{\rho_2} \end{cases} \tag{7.1}$$

where $\Delta W_1(p_{1B}, p_{2B}^*) \equiv W(p_{1B}, p_{2B}^*) - W(\infty, p_{2B}^*)$, $\Delta W_2(p_{1B}^*, p_{2B}) \equiv W(p_{1B}^*, p_{2B}) - W(p_{1B}^*, \infty)$, and $\rho_1, \rho_2 \in (0, 1]$ capture the bargaining power of the governmental agency in its negotiation with firms 1 and 2, respectively. We assume that the pair (p_{1B}^*, p_{2B}^*) solving the system exists and is unique.

We now consider the international reference pricing equilibrium that satisfies

$$\begin{cases} p_{1A}^{**} = \tilde{p}_{1A}(p_{1B}^{**}, p_{2A}^{**}) \equiv \underset{p_{1A} \leq p_{1B}^{**}}{\arg\max} \Pi_{1A}(p_{1A}, p_{2A}^{**}) \\ p_{2A}^{**} = \tilde{p}_{2A}(p_{1A}^{**}, p_{2B}^{**}) \equiv \underset{p_{2A} \leq p_{2B}^{**}}{\arg\max} \Pi_{2A}(p_{1A}^{**}, p_{2A}) \\ p_{1B}^{**} = \underset{p_{1B} \geq c}{\arg\max} \left[\Pi_{1A}(\tilde{p}_{1A}(p_{1B}, p_{2A}^{**}), p_{2A}^{**}) + \Pi_{1B}(p_{1B}, p_{2B}^{**}) - \Pi_{1A}(p_{1A}^*, p_{2A}^{**})\right]^{1-\rho_1} \Delta W_1(p_{1B}, p_{2B}^{**})^{\rho_1} \\ p_{2B}^{**} = \underset{p_{2B} \geq c}{\arg\max} \left[\Pi_{2A}(p_{1A}^{**}, \tilde{p}_{2A}(p_{1A}^{**}, p_{2B})) + \Pi_{2B}(p_{1B}^{**}, p_{2B}) - \Pi_{2A}(p_{1A}^{**}, p_{2A}^*)\right]^{1-\rho_2} \Delta W_2(p_{1B}^{**}, p_{2B})^{\rho_2} \end{cases}$$

Remark that imposing the reference pricing constraint on one product only would generate the same proposition, but for simplicity of exposition we consider the symmetric case.

Proposition The international reference pricing policy implies that the prices in country A decrease and the prices in country B increase:

$$p_{iA}^{**} \leq p_{iA}^{*} \quad \text{and} \quad p_{iB}^{**} \geq p_{iB}^{*} \quad \text{for } i = 1, 2$$

Proof *Let's start with proving that $p_{iA}^{**} \leq p_{iA}^{*}$ for $i = 1, 2$:*

By definition of the solution of

$$\begin{cases} p_{1A}^{*} = \tilde{p}_{1A}\left(\infty, p_{2A}^{*}\right) = \underset{p_{1A}}{\arg\max} \Pi_{1A}\left(p_{1A}, p_{2A}^{*}\right) \\ p_{2A}^{*} = \tilde{p}_{2A}\left(p_{1A}^{*}, \infty\right) = \underset{p_{2A}}{\arg\max} \Pi_{2A}\left(p_{1A}^{*}, p_{2A}\right) \end{cases}$$

and

$$\begin{cases} p_{1A}^{**} = \tilde{p}_{1A}\left(p_{1B}^{**}, p_{2A}^{**}\right) \equiv \underset{p_{1A} \leq p_{1B}^{**}}{\arg\max} \Pi_{1A}\left(p_{1A}, p_{2A}^{**}\right) \\ p_{2A}^{**} = \tilde{p}_{2A}\left(p_{1A}^{**}, p_{2B}^{**}\right) \equiv \underset{p_{2A} \leq p_{2B}^{**}}{\arg\max} \Pi_{2A}\left(p_{1A}^{**}, p_{2A}\right) \end{cases}$$

Then

$$\begin{aligned} p_{1A}^{**} &= \tilde{p}_{1A}\left(p_{1B}^{**}, p_{2A}^{**}\right) \leq \tilde{p}_{1A}\left(\infty, p_{2A}^{**}\right) \leq \tilde{p}_{1A}\left(\infty, p_{2A}^{*}\right) = p_{1A}^{*} \text{ if } p_{2A}^{**} \leq p_{2A}^{*} \\ p_{2A}^{**} &= \tilde{p}_{2A}\left(p_{1A}^{**}, p_{2B}^{**}\right) \leq \tilde{p}_{2A}\left(p_{1A}^{**}, \infty\right) \leq \tilde{p}_{2A}\left(p_{1A}^{*}, \infty\right) = p_{2A}^{*} \text{ if } p_{1A}^{**} \leq p_{1A}^{*} \end{aligned}$$

If $p_{1A}^{**} > p_{1A}^{*}$ then $p_{2A}^{**} = \tilde{p}_{2A}\left(p_{1A}^{**}, p_{2B}^{**}\right) \geq \tilde{p}_{2A}\left(p_{1A}^{*}, p_{2B}^{**}\right) = p_{2A}^{*}$ if $p_{2B}^{**} \geq p_{2A}^{*}$. Thus $p_{1A}^{**} > p_{1A}^{*}$ implies $p_{2A}^{**} > p_{2A}^{*}$ if $p_{2B}^{**} \geq p_{2A}^{*}$, but both prices increasing is not possible by definition of the unconstrained Nash equilibrium. Thus, it must be that if $p_{1A}^{**} > p_{1A}^{*}$ then $p_{2B}^{**} < p_{2A}^{*}$, but then $p_{2A}^{**} \leq p_{2B}^{**} < p_{2A}^{*}$. But we have shown that if $p_{2A}^{**} \leq p_{2A}^{*}$ then $p_{1A}^{**} \leq p_{1A}^{*}$ which proves that we must have both $p_{iA}^{**} \leq p_{iA}^{*}$ for $i = 1, 2$.

Let's prove now that $p_{iB}^{**} \geq p_{iB}^{*}$ for $i = 1, 2$:

Remark that $\tilde{p}_{1A}(p_{1B}, p_{2A})$ is weakly increasing in the second argument p_{2A} because of strategic complementarity in profit, and symmetrically for $\tilde{p}_{2A}(.,.)$.

Moreover, $\tilde{p}_{1A}(p_{1B}, p_{2A})$ is weakly increasing in the first argument p_{1B} because of the concavity of the profit function in its own price.

Moreover, $\tilde{p}_{1A}(p_{1B}, p_{2A}^{**}) \leq \tilde{p}_{1A}(p_{1B}, p_{2A}^{*})$ and $\tilde{p}_{2A}\left(p_{1A}^{**}, p_{2B}\right) \leq \tilde{p}_{2A}\left(p_{1A}^{*}, p_{2B}\right)$ since $p_{iA}^{**} \leq p_{iA}^{*}$.

Then, $\tilde{p}_{1A}(p_{1B}, p_{2A}^{*}) \leq p_{1A}^{*}$ and thus $\tilde{p}_{1A}(p_{1B}, p_{2A}^{**}) \leq p_{1A}^{*}$ which implies that

$$\Delta\Pi_{1A}\left(p_{1B}, p_{1A}^{*}, p_{2A}^{**}\right) \equiv \Pi_{1A}\left(\tilde{p}_{1A}\left(p_{1B}, p_{2A}^{**}\right), p_{2A}^{**}\right) - \Pi_{1A}\left(p_{1A}^{*}, p_{2A}^{**}\right) \leq 0$$

because the reaction function of firm 2 is increasing in the price of firm 1. Similarly $\Pi_{2A}\left(p_{1A}^{**},\tilde{p}_{2A}\left(p_{1A}^{**},p_{2B}\right)\right)-\Pi_{2A}\left(p_{1A}^{**},p_{2A}^{*}\right)\leq 0$.

Moreover, $\Pi_{1A}\left(\tilde{p}_{1A}\left(p_{1B},p_{2A}^{**}\right),p_{2A}^{**}\right)-\Pi_{1A}\left(p_{1A}^{*},p_{2A}^{**}\right)$ is then weakly increasing in p_{1B} as well as $\Pi_{2A}\left(p_{1A}^{**},\tilde{p}_{2A}\left(p_{1A}^{**},p_{2B}\right)\right)-\Pi_{2A}\left(p_{1A}^{**},p_{2A}^{*}\right)$ in p_{2B}.

$\Delta W_1\left(p_{1B},p_{2B}^{*}\right)\equiv W\left(p_{1B},p_{2B}^{*}\right)-W\left(\infty,p_{2B}^{*}\right)\geq 0$ is decreasing in p_{1B} and $\Delta W_2\left(p_{1B}^{*},p_{2B}\right)\equiv W\left(p_{1B}^{*},p_{2B}\right)-W\left(p_{1B}^{*},\infty\right)\geq 0$ is decreasing in p_{2B}.

Define

$$\tilde{\Pi}_{1B}\left(p_{1B},p_{1A}^{*},p_{2A}^{**},p_{2B}^{**}\right)=\Pi_{1A}\left(\tilde{p}_{1A}\left(p_{1B},p_{2A}^{**}\right),p_{2A}^{**}\right)+\Pi_{1B}\left(p_{1B},p_{2B}^{**}\right)-\Pi_{1A}\left(p_{1A}^{*},p_{2A}^{**}\right)$$

and

$$\tilde{\Pi}_{2B}\left(p_{2B},p_{2A}^{*},p_{1A}^{**},p_{1B}^{**}\right)=\Pi_{2A}\left(p_{1A}^{**},\tilde{p}_{2A}\left(p_{1A}^{**},p_{2B}\right)\right)+\Pi_{2B}\left(p_{1B}^{**},p_{2B}\right)-\Pi_{2A}\left(p_{1A}^{**},p_{2A}^{*}\right)$$

As $\Pi_{1B}\left(p_{1B},p_{2B}\right)$ is increasing in p_{1B} for $p_{1B}\leq\bar{p}_{1B}\left(p_{2B}\right)$ and increasing in p_{2B}, we have that $\tilde{\Pi}_{1B}\left(p_{1B},p_{1A}^{*},p_{2A}^{**},p_{2B}^{**}\right)$ is increasing in p_{1B} for $p_{1B}\leq\bar{p}_{1B}\left(p_{2B}\right)$ and increasing in p_{2B}^{**}. Symmetrically, $\tilde{\Pi}_{2B}\left(p_{2B},p_{2A}^{*},p_{1A}^{**},p_{1B}^{**}\right)$ is increasing in p_{2B} for $p_{2B}\leq\bar{p}_{2B}\left(p_{1B}\right)$ and increasing in p_{1B}^{**}.

Moreover, because of the previous inequalities, $\tilde{\Pi}_{1B}\left(p_{1B},p_{1A}^{*},p_{2A}^{**},p_{2B}^{**}\right)\leq\Pi_{1B}\left(p_{1B},p_{2B}^{**}\right)$ and $\tilde{\Pi}_{2B}\left(p_{2B},p_{2A}^{*},p_{1A}^{**},p_{1B}^{**}\right)\leq\Pi_{2B}\left(p_{1B}^{**},p_{2B}\right)$.

Then

$$\begin{aligned}
&\left[\Pi_{1A}\left(\tilde{p}_{1A}\left(p_{1B}^{**},p_{2A}^{**}\right),p_{2A}^{**}\right)-\Pi_{1A}\left(p_{1A}^{*},p_{2A}^{**}\right)\right]\Delta W_1\left(p_{1B}^{**},p_{2B}^{**}\right)^{\frac{\rho_1}{1-\rho_1}}+\Pi_{1B}\left(p_{1B}^{**},p_{2B}^{**}\right)\Delta W_1\left(p_{1B}^{**},p_{2B}^{**}\right)^{\frac{\rho_1}{1-\rho_1}}\\
=\;&\left[\Pi_{1A}\left(\tilde{p}_{1A}\left(p_{1B}^{**},p_{2A}^{**}\right),p_{2A}^{**}\right)+\Pi_{1B}\left(p_{1B}^{**},p_{2B}^{**}\right)-\Pi_{1A}\left(p_{1A}^{*},p_{2A}^{**}\right)\right]\Delta W_1\left(p_{1B}^{**},p_{2B}^{**}\right)^{\frac{\rho_1}{1-\rho_1}}\\
\geq\;&\left[\Pi_{1A}\left(\tilde{p}_{1A}\left(p_{1B}^{*},p_{2A}^{**}\right),p_{2A}^{**}\right)+\Pi_{1B}\left(p_{1B}^{*},p_{2B}^{**}\right)-\Pi_{1A}\left(p_{1A}^{*},p_{2A}^{**}\right)\right]\Delta W_1\left(p_{1B}^{*},p_{2B}^{**}\right)^{\frac{\rho_1}{1-\rho_1}}\\
&\text{because of the definition of } p_{1B}^{**}\\
=\;&\left[\Pi_{1A}\left(\tilde{p}_{1A}\left(p_{1B}^{*},p_{2A}^{**}\right),p_{2A}^{**}\right)-\Pi_{1A}\left(p_{1A}^{*},p_{2A}^{**}\right)\right]\Delta W_1\left(p_{1B}^{*},p_{2B}^{**}\right)^{\frac{\rho_1}{1-\rho_1}}+\Pi_{1B}\left(p_{1B}^{*},p_{2B}^{**}\right)\Delta W_1\left(p_{1B}^{*},p_{2B}^{**}\right)^{\frac{\rho_1}{1-\rho_1}}\\
\geq\;&\left[\Pi_{1A}\left(\tilde{p}_{1A}\left(p_{1B}^{*},p_{2A}^{**}\right),p_{2A}^{**}\right)-\Pi_{1A}\left(p_{1A}^{*},p_{2A}^{**}\right)\right]\Delta W_1\left(p_{1B}^{*},p_{2B}^{**}\right)^{\frac{\rho_1}{1-\rho_1}}+\Pi_{1B}\left(p_{1B}^{**},p_{2B}^{**}\right)\Delta W_1\left(p_{1B}^{**},p_{2B}^{**}\right)^{\frac{\rho_1}{1-\rho_1}}\\
&\text{because of the definition of } p_{1B}^{*}
\end{aligned}$$

then, using the fact that $\Delta\Pi_{1A}\left(p_{1B}^{**},p_{1A}^{*},p_{2A}^{**}\right)=\Pi_{1A}\left(\tilde{p}_{1A}\left(p_{1B}^{**},p_{2A}^{**}\right),p_{2A}^{**}\right)-\Pi_{1A}\left(p_{1A}^{*},p_{2A}^{**}\right)$ and $\Delta\Pi_{1A}\left(p_{1B}^{*},p_{1A}^{*},p_{2A}^{**}\right)=\Pi_{1A}\left(\tilde{p}_{1A}\left(p_{1B}^{*},p_{2A}^{**}\right),p_{2A}^{**}\right)-\Pi_{1A}\left(p_{1A}^{*},p_{2A}^{**}\right)$ the previous inequality

implies that

$$\Delta\Pi_{1A}\left(p_{1B}^{**},p_{1A}^{*},p_{2A}^{**}\right)\Delta W_1\left(p_{1B}^{**},p_{2B}^{**}\right)^{\frac{\rho_1}{1-\rho_1}}\geq\Delta\Pi_{1A}\left(p_{1B}^{*},p_{1A}^{*},p_{2A}^{**}\right)\Delta W_1\left(p_{1B}^{*},p_{2B}^{**}\right)^{\frac{\rho_1}{1-\rho_1}}$$

thus

$$\left(\frac{\Delta W_1\left(p_{1B}^{**},p_{2B}^{**}\right)}{\Delta W_1\left(p_{1B}^{*},p_{2B}^{**}\right)}\right)^{\frac{\rho_1}{1-\rho_1}}\leq\frac{\Delta\Pi_{1A}\left(p_{1B}^{*},p_{1A}^{*},p_{2A}^{**}\right)}{\Delta\Pi_{1A}\left(p_{1B}^{**},p_{1A}^{*},p_{2A}^{**}\right)}$$

because $\Delta\Pi_{1A}\left(p_{1B}^{**},p_{1A}^{*},p_{2A}^{**}\right)\leq 0$.

This inequality if not possible if $p_{1B}^{**}<p_{1B}^{*}$ because in such case $\frac{\Delta W_1\left(p_{1B}^{**},p_{2B}^{**}\right)}{\Delta W_1\left(p_{1B}^{*},p_{2B}^{**}\right)}>1$ because $\Delta W_1\left(p_{1B},p_{2B}\right)$ is decreasing in p_{1B}, and $\frac{\Delta\Pi_{1A}\left(p_{1B}^{*},p_{1A}^{*},p_{2A}^{**}\right)}{\Delta\Pi_{1A}\left(p_{1B}^{**},p_{1A}^{*},p_{2A}^{**}\right)}\leq 1$ because $\Delta\Pi_{1A}\left(p_{1B},p_{1A}^{*},p_{2A}^{**}\right)$ is increasing in p_{1B} but negative. This implies that necessarily $p_{1B}^{**}\geq p_{1B}^{*}$. Symmetrically $p_{2B}^{**}\geq p_{2B}^{*}$.

7.5 Additional Tables of counterfactuals

7.5.1 Counterfactuals with Canada as Price Ceiling for the US

Table 7.5: *Counterfactual Expenses Changes on All Drugs with Canada as Price Ceiling*

	ρ_{jm}			Canada			US		
ATC4	*On Patent*	*Branded Off*	*Generic*	Before	After	Δ (%)	Before	After	Δ (%)
A10C1	0.62			4161	5777	38.8	113984	112471	-1.3
A2B2	0.55	0.90	0.87	14057	26529	88.7	270730	272016	0.5
B1B2	0.70			40084	78711	96.4	1326672	1292428	-2.6
C10A1	0.54	1.00	0.77	14549	24038	65.2	171667	172718	0.6
C2A2	1.00	1.00	0.94	1484	1484	-0.0	36579	36579	0.0
C7A0	0.72	1.00	1.00	5103	5144	0.8	143544	143553	0.0
C8A0	0.56	0.89	0.86	11908	14573	22.4	247149	245348	-0.7
C9A0	0.47	0.95	1.00	9728	10512	8.1	57229	59278	3.6
C9C0	0.60	0.94	0.50	4588	8040	75.2	63460	63616	0.2
L1A0	0.91	0.50	1.00	12525	22054	76.1	232379	231182	-0.5
L1B0	0.64	0.50	1.00	33075	60786	83.8	449600	418495	-6.9
L1C0	0.50	0.50	0.98	90792	103251	13.7	629957	649874	3.2
L1D0	0.99	0.50	0.50	20424	23867	16.9	171677	171784	0.1
L1X4	1.00	0.50	0.50	51978	65939	26.9	83862	83630	-0.3
L1X9	0.92	0.50	0.57	19173	19416	1.3	141652	141573	-0.1
L2B2	0.83	0.94	0.61	3808	4881	28.2	7079	7281	2.9
L2B3	0.70	0.79	0.58	9413	16216	72.3	10846	10606	-2.2
L4X0	0.95	0.91	1.00	37386	103864	177.8	275654	274975	-0.2
M1A1	0.44	0.91	1.00	1604	5179	223.0	26505	26865	1.4
M5B3	0.93	0.95	0.54	2455	2837	15.5	31052	30933	-0.4
N1A1	0.45	0.57	1.00	15417	19358	25.6	543474	541875	-0.3
N1A2	1.00	1.00	0.92	14275	14395	0.8	627990	628001	0.0
N1B1	0.96	1.00	0.75	4917	5142	4.6	88133	88144	0.0
N1B3	0.50	0.50	0.58	14496	14496	0.0	152988	152988	-0.0
N2A0	0.51	0.78	0.89	21736	21737	0.0	464444	464445	0.0
N2B0	0.50	0.96	0.88	3135	4058	29.4	81298	81300	0.0
N3A0	0.87	0.93	1.00	11366	21739	91.3	438695	439107	0.1
N5A1	0.86	0.86	0.94	74422	138244	85.8	1039056	1033974	-0.5
N5A9	0.64	0.97	0.94	4746	4746	0.0	46400	46398	-0.0
N6A4	0.80	0.99	0.91	6183	6110	-1.2	149528	149454	-0.0
N6A9	0.27	0.89	0.99	2245	2258	0.6	46742	46767	0.1
Total				561233	855382	52.4	8170027	8117658	-.6

Note: Expenses are average yearly expenses in 1000 US$ (from the period 2002-2013). Δ stands for the change in expenses between after and before in percentage of initial expenses. The parameter ρ_{jm} is the one estimated from the supply model in Canada and used for counterfactual simulations.

Table 7.6: *Counterfactual Quantity Changes on All Drugs with Canada as Price Ceiling*

	ρ_{jm}			Canada			US		
ATC4	On Patent	Branded Off	Generic	Before	After	Δ (%)	Before	After	Δ (%)
A10C1	0.62			349	249	-28.6	3302	3317	0.5
A2B2	0.55	0.90	0.87	19362	16020	-17.3	113244	114653	1.2
B1B2	0.70			2598	2306	-11.2	35354	35556	0.6
C10A1	0.54	1.00	0.77	11349	10431	-8.1	79186	80203	1.3
C2A2	1.00	1.00	0.94	2384	2384	0.0	26882	26882	-0.0
C7A0	0.72	1.00	1.00	23492	23401	-0.4	167276	167278	0.0
C8A0	0.56	0.89	0.86	12760	12477	-2.2	73390	73697	0.4
C9A0	0.47	0.95	1.00	18050	14721	-18.4	101954	103864	1.9
C9C0	0.60	0.94	0.50	4801	4458	-7.1	27227	27982	2.8
L1A0	0.91	0.50	1.00	795	675	-15.1	1793	1795	0.1
L1B0	0.64	0.50	1.00	2320	1591	-31.4	3737	3791	1.4
L1C0	0.50	0.50	0.98	332	299	-10.2	1424	1460	2.5
L1D0	0.99	0.50	0.50	123	116	-5.2	522	522	0.0
L1X4	1.00	0.50	0.50	785	556	-29.3	722	723	0.1
L1X9	0.92	0.50	0.57	755	753	-0.3	994	994	0.0
L2B2	0.83	0.94	0.61	1791	1739	-2.9	677	690	2.0
L2B3	0.70	0.79	0.58	1928	1648	-14.6	917	1033	12.7
L4X0	0.95	0.91	1.00	12181	8232	-32.4	11599	11666	0.6
M1A1	0.44	0.91	1.00	8374	5944	-29.0	99443	99592	0.1
M5B3	0.93	0.95	0.54	1225	1079	-11.9	1823	1826	0.2
N1A1	0.45	0.57	1.00	19107	17776	-7.0	665328	665934	0.1
N1A2	1.00	1.00	0.92	2865	2828	-1.3	69548	69548	0.0
N1B1	0.96	1.00	0.75	1096	1080	-1.4	20315	20315	0.0
N1B3	0.50	0.50	0.58	16254	16254	0.0	145882	145882	-0.0
N2A0	0.51	0.78	0.89	36395	36395	-0.0	343829	343829	0.0
N2B0	0.50	0.96	0.88	10159	9870	-2.8	153266	153266	-0.0
N3A0	0.87	0.93	1.00	42619	39004	-8.5	274813	275012	0.1
N5A1	0.86	0.86	0.94	41625	32705	-21.4	115139	115470	0.3
N5A9	0.64	0.97	0.94	9269	9267	-0.0	36694	36694	0.0
N6A4	0.80	0.99	0.91	13805	12720	-7.9	89527	89578	0.1
N6A9	0.27	0.89	0.99	11944	11890	-0.4	72854	72876	0.0
Total				330892	298869	-9.6	2738661	2745930	.2

Note: Quantity are average yearly standard units (on period 2002-2013). Δ stands for the change of quantity between after and before in percentage of initial quantity. The parameter ρ_{jm} is the one estimated from the supply model in Canada and used for counterfactual simulations.

Table 7.7: *Counterfactual Profits on All Drugs with Canada as Price Ceiling*

	ρ_{jm}			Canada			US		
ATC4	On Patent	Branded Off	Generic	Before	After	Δ (%)	Before	After	Δ (%)
A10C1	0.62			3147	5123	62.8	97767	95925	-1.9
A2B2	0.55	0.90	0.87	11212	23988	114.0	143282	142252	-0.7
B1B2	0.70			37401	75708	102.4	1279709	1243295	-2.8
C10A1	0.54	1.00	0.77	12037	21953	82.4	89953	88070	-2.1
C2A2	1.00	1.00	0.94	1439	1439	-0.0	4260	4260	0.0
C7A0	0.72	1.00	1.00	4853	4905	1.1	27738	27734	-0.0
C8A0	0.56	0.89	0.86	9790	12714	29.9	97479	96582	-0.9
C9A0	0.47	0.95	1.00	5921	7716	30.3	14233	13947	-2.0
C9C0	0.60	0.94	0.50	3139	6715	113.9	32509	31673	-2.6
L1A0	0.91	0.50	1.00	12000	21508	79.2	91496	90799	-0.8
L1B0	0.64	0.50	1.00	24193	51007	110.8	190112	170679	-10.2
L1C0	0.50	0.50	0.98	50263	72748	44.7	269879	265900	-1.5
L1D0	0.99	0.50	0.50	14564	17221	18.2	61282	61162	-0.2
L1X4	1.00	0.50	0.50	50602	64535	27.5	43552	43253	-0.7
L1X9	0.92	0.50	0.57	17276	17571	1.7	60304	60223	-0.1
L2B2	0.83	0.94	0.61	3468	4594	32.5	3503	3462	-1.2
L2B3	0.70	0.79	0.58	8559	15482	80.9	6585	5623	-14.6
L4X0	0.95	0.91	1.00	36855	102785	178.9	77871	77508	-0.5
M1A1	0.44	0.91	1.00	1319	4670	254.1	2592	2519	-2.8
M5B3	0.93	0.95	0.54	2151	2532	17.7	19601	19477	-0.6
N1A1	0.45	0.57	1.00	12530	16762	33.8	349549	347992	-0.4
N1A2	1.00	1.00	0.92	13656	13792	1.0	157280	157277	-0.0
N1B1	0.96	1.00	0.75	4678	4904	4.8	20696	20695	-0.0
N1B3	0.50	0.50	0.58	9221	9221	0.0	20075	20075	0.0
N2A0	0.51	0.78	0.89	19276	19278	0.0	45855	45855	0.0
N2B0	0.50	0.96	0.88	2984	3842	28.8	10947	10948	0.0
N3A0	0.87	0.93	1.00	10688	21015	96.6	116621	116554	-0.1
N5A1	0.86	0.86	0.94	69988	133776	91.1	526368	520215	-1.2
N5A9	0.64	0.97	0.94	3851	3852	0.0	3148	3147	-0.0
N6A4	0.80	0.99	0.91	5084	5371	5.6	70404	70171	-0.3
N6A9	0.27	0.89	0.99	1878	1913	1.9	13149	13123	-0.2
Total				464022	768639	65.59	3947799	3870395	-1.9

Note: Profits are average yearly expenses in 1000 US$ (from the period 2002-2013). Δ stands for the change in profits between after and before in percentage of initial profits. The parameter ρ_j is the one estimated from the supply model in Canada and used for counterfactual simulations.

Table 7.8: *Counterfactual Expenses on Patented Drugs when Canada as Price Ceiling*

		ρ_{jm}		Canada			US		
ATC4	*On Patent*	*Branded Off*	*Generic*	Before	After	Δ (%)	Before	After	Δ (%)
A10C1	0.62			4161	5777	38.8	113984	112471	-1.3
A2B2	0.55	0.90	0.87	9018	17984	99.4	182955	184476	0.8
B1B2	0.70			40084	78711	96.4	1261933	1228934	-2.6
C10A1	0.54	1.00	0.77	11938	19425	62.7	139298	141079	1.3
C2A2	1.00	1.00	0.94	761	761	-0.0	8330	8330	0.0
C7A0	0.72	1.00	1.00	311	319	2.9	27376	27387	0.0
C8A0	0.56	0.89	0.86	7317	8807	20.4	47992	48490	1.0
C9A0	0.47	0.95	1.00	6881	7465	8.5	23967	26246	9.5
C9C0	0.60	0.94	0.50	4056	7452	83.7	61146	61340	0.3
L1A0	0.91	0.50	1.00	10281	18019	75.3	170467	169746	-0.4
L1B0	0.64	0.50	1.00	25159	45386	80.4	392044	364805	-6.9
L1C0	0.50	0.50	0.98	74104	84637	14.2	524380	545884	4.1
L1D0	0.99	0.50	0.50	8457	10106	19.5	65298	65527	0.4
L1X4	1.00	0.50	0.50	49887	63476	27.2	83505	83278	-0.3
L1X9	0.92	0.50	0.57	18322	18545	1.2	129433	129361	-0.1
L2B2	0.83	0.94	0.61	2638	3473	31.7	6229	6442	3.4
L2B3	0.70	0.79	0.58	9158	15905	73.7	10671	10439	-2.2
L4X0	0.95	0.91	1.00	35121	95430	171.7	152335	152260	-0.0
M1A1	0.44	0.91	1.00	438	1476	237.0	2867	3268	14.0
M5B3	0.93	0.95	0.54	1238	1413	14.1	27912	27806	-0.4
N1A1	0.45	0.57	1.00	6900	8619	24.9	350707	350088	-0.2
N1A2	1.00	1.00	0.92	1192	1171	-1.8	70722	70740	0.0
N1B1	0.96	1.00	0.75	1456	1508	3.5	31019	31035	0.0
N1B3	0.50	0.50	0.58	923	923	-0.0	1362	1362	-0.0
N2A0	0.51	0.78	0.89	346	346	-0.0	870	871	0.1
N2B0	0.50	0.96	0.88	180	273	51.3	18975	18976	0.0
N3A0	0.87	0.93	1.00	3541	6502	83.6	195096	195655	0.3
N5A1	0.86	0.86	0.94	32795	67883	107.0	966832	962088	-0.5
N5A9	0.64	0.97	0.94	1716	1716	0.0	1153	1154	0.1
N6A4	0.80	0.99	0.91	2473	2371	-4.1	113105	113115	0.0
N6A9	0.27	0.89	0.99	341	344	0.8	4674	4738	1.4
Total				371191	596221	60.62	5186638	5147393	-.75

Note: Expenses are average yearly expenses in 1000 US$ (on period 2002-2013). Patented drugs only.

Table 7.9: *Counterfactual Price Changes by ATC-4 when Canada as Price Ceiling*

ATC4	ρ_{jm} On Patent	ρ_{jm} Branded Off	ρ_{jm} Generic	Price Change All drugs CA (%)	Price Change All drugs US (%)	Price Change Patented CA (%)	Price Change Patented US (%)	Price Change Branded Off CA (%)	Price Change Branded Off US (%)	Price Change Generic CA (%)	Price Change Generic US (%)
A10C1	0.62			81.1	-1.7	81.1	-1.7				
A2B2	0.55	0.90	0.87	132.1	-0.7	197.6	-1.3	88.2	-0.1	23.9	-0.1
B1B2	0.70			122.1	-3.1	122.1	-3.2		-2.1		0.0
C10A1	0.54	1.00	0.77	78.5	-0.8	117.8	-2.6	166.8	-1.7	36.0	-0.2
C2A2	1.00	1.00	0.94	-0.0	0.0	-0.0	0.0	0.0	0.0	-0.0	0.0
C7A0	0.72	1.00	1.00	1.5	0.0	3.3	-0.1	0.5	0.0	1.1	0.0
C8A0	0.56	0.89	0.86	25.9	-1.1	43.0	-2.8	16.3	0.4	17.7	-0.2
C9A0	0.47	0.95	1.00	29.1	1.9	66.1	-6.5	1.8	0.0	5.4	-0.1
C9C0	0.60	0.94	0.50	92.6	-2.3	104.9	-2.9	19.5	0.4	1.7	-0.8
L1A0	0.91	0.50	1.00	111.6	-0.6	212.7	-1.3	16.8	-0.6	133.9	0.0
L1B0	0.64	0.50	1.00	156.4	-8.5	199.3	-21.7	-0.5	-3.0	118.4	-0.4
L1C0	0.50	0.50	0.98	26.8	0.6	66.9	-4.6	-1.5	0.2	6.6	-0.1
L1D0	0.99	0.50	0.50	21.0	0.1	173.6	-0.5	-3.0	-0.0	2.3	-0.0
L1X4	1.00	0.50	0.50	81.6	-0.4	85.4	-0.4	3.8		0.0	0.0
L1X9	0.92	0.50	0.57	1.6	-0.1	52.8	-0.5	1.5		2.2	0.0
L2B2	0.83	0.94	0.61	31.3	1.6	245.1	-3.9	15.5	0.3	10.1	0.1
L2B3	0.70	0.79	0.58	101.7	-13.4	104.6	-14.0	19.0	-0.4	11.2	-0.0
L4X0	0.95	0.91	1.00	312.0	-0.9	329.7	-1.2	5.2	-0.1	126.9	0.0
M1A1	0.44	0.91	1.00	358.0	1.1	104.4	-17.1	63.6	-0.1	494.4	-0.0
M5B3	0.93	0.95	0.54	24.8	-0.5	56.6	-0.8	21.1	0.3	2.4	-0.1
N1A1	0.45	0.57	1.00	35.4	-0.4	48.1	-0.7	23.0	-0.1	25.0	0.0
N1A2	1.00	1.00	0.92	2.3	0.0	41.4	-0.1	1.8	-0.0	1.4	0.0
N1B1	0.96	1.00	0.75	6.7	0.0	16.2	-0.0	10.1	-0.0	4.3	0.0
N1B3	0.50	0.50	0.58	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
N2A0	0.51	0.78	0.89	0.0	0.0	0.1	-0.1	-0.0	-0.0	0.0	0.0
N2B0	0.50	0.96	0.88	29.0	0.0	4.5	0.0	22.8	0.0	30.3	0.0
N3A0	0.87	0.93	1.00	116.5	0.0	128.8	-0.5	79.2	-0.0	132.3	0.0
N5A1	0.86	0.86	0.94	136.5	-0.7	374.2	-1.0	52.3	0.2	49.1	0.4
N5A9	0.64	0.97	0.94	0.0	-0.0	0.5	-0.3	-0.0	0.0	0.0	0.0
N6A4	0.80	0.99	0.91	9.5	-0.1	146.8	-0.4	0.4	-0.1	0.4	0.0
N6A9	0.27	0.89	0.99	1.1	0.0	6.4	-3.1	-0.1	-0.0	0.8	0.0

Note: Changes in % of initial price using market shares weighted average prices.

Table 7.10: *Counterfactual Prices of Drugs on Patent present in both US and Canada when Canada as Price Ceiling*

	Before		After			
	Canada	US	Canada		US	
ATC4	Price	Price	Price	Δ (%)	Price	Δ (%)
A10C1	12.8661	36.95631	28.68712	122.97	36.33642	-1.68
A2B2	.8079825	2.675094	2.697367	233.84	2.638698	-1.36
B1B2	15.55126	38.01187	37.48726	141.06	36.81441	-3.15
C10A1	1.770697	3.82358	3.857452	117.85	3.676275	-3.85
C2A2	54.75095	13.18811	54.74297	-0.01	13.18826	0.00
C7A0	1.244643	7.688396	2.174808	74.73	7.643762	-0.58
C8A0	1.268361	2.297664	2.244284	76.94	2.229781	-2.95
C9A0	.5956708	1.685162	1.66685	179.83	1.553767	-7.80
C9C0	1.094559	2.528681	2.301818	110.30	2.441019	-3.47
L1A0	24.69844	198.238	77.59502	214.17	195.6298	-1.32
L1B0	17.69059	248.5182	67.17113	279.70	191.2764	-23.03
L1C0	471.2581	1033.659	941.1678	99.71	978.6742	-5.32
L1D0	292.0294	780.7533	1259.364	331.25	778.822	-0.25
L1X4	66.59953	99.22975	125.9008	89.04	98.87067	-0.36
L1X9	647.0916	745.1591	993.0546	53.46	737.4075	-1.04
L2B2	10.43049	32.88236	35.99053	245.05	30.63242	-6.84
L2B3	4.868706	11.67673	10.1707	108.90	9.953807	-14.76
L4X0	3.17295	9.958714	14.10345	344.49	9.872184	-0.87
M1A1	.6490896	2.914528	2.132971	228.61	2.231462	-23.44
M5B3	6.017537	14.48667	17.12974	184.66	14.33339	-1.06
N1A1	.662663	.919805	1.02603	54.83	.9137184	-0.66
N1A2	12.79765	75.2755	31.65229	147.33	75.17899	-0.13
N1B1	13.03696	16.28716	16.25504	24.68	16.27825	-0.05
N1B3						
N2A0	1.003563	3.317234	3.377676	236.57	3.313498	-0.11
N2B0						
N3A0	1.384019	3.735585	3.399423	145.62	3.694843	-1.09
N5A1	1.760912	8.886744	8.998435	411.01	8.755308	-1.48
N5A9	.8207119	1.356838	1.303776	58.86	1.313062	-3.23
N6A4	1.334195	3.653124	3.66085	174.39	3.634008	-0.52
N6A9	.6356424	3.21982	1.843886	190.08	3.059738	-4.97

Note: Market shares weighted average price of patented drugs by ATC-4, country for drugs present in both only. Percentage changes are changes with respect to the initial situation.

Table 7.11: *Counterfactual Consumer Welfare Changes on All Drugs when Canada as Price Ceiling*

		ρ_{jm}		Canada			US		
ATC4	On Patent	Branded Off	Generic	Before	After	Δ (%)	Before	After	Δ (%)
A10C1	0.62			885	984	11.3	11159	11317	1.4
A2B2	0.55	0.90	0.87	56646	42825	-24.4	337119	339633	0.7
B1B2	0.70			8804	6711	-23.8	120918	123494	2.1
C10A1	0.54	1.00	0.77	37661	30663	-18.6	242072	245518	1.4
C2A2	1.00	1.00	0.94	7111	7111	0.0	88937	88936	-0.0
C7A0	0.72	1.00	1.00	62951	62610	-0.5	675640	675647	0.0
C8A0	0.56	0.89	0.86	44044	40952	-7.0	230677	232046	0.6
C9A0	0.47	0.95	1.00	51194	46325	-9.5	335249	337842	0.8
C9C0	0.60	0.94	0.50	16875	14186	-15.9	72193	73773	2.2
L1A0	0.91	0.50	1.00	2395	1835	-23.4	6204	6220	0.3
L1B0	0.64	0.50	1.00	6643	4688	-29.4	12862	13171	2.4
L1C0	0.50	0.50	0.98	855	773	-9.6	4061	4119	1.4
L1D0	0.99	0.50	0.50	363	336	-7.5	2161	2162	0.0
L1X4	1.00	0.50	0.50	2126	1725	-18.9	2109	2116	0.3
L1X9	0.92	0.50	0.57	2431	2413	-0.8	3561	3562	0.0
L2B2	0.83	0.94	0.61	6150	5700	-7.3	2158	2181	1.1
L2B3	0.70	0.79	0.58	5894	4575	-22.4	2478	2806	13.3
L4X0	0.95	0.91	1.00	35194	20803	-40.9	29593	29734	0.5
M1A1	0.44	0.91	1.00	27343	16265	-40.5	389901	390104	0.1
M5B3	0.93	0.95	0.54	3244	2908	-10.4	5887	5913	0.4
N1A1	0.45	0.57	1.00	55089	49074	-10.9	2307142	2313437	0.3
N1A2	1.00	1.00	0.92	9216	9144	-0.8	260259	260260	0.0
N1B1	0.96	1.00	0.75	2969	2898	-2.4	76524	76527	0.0
N1B3	0.50	0.50	0.58	48316	48316	0.0	736051	736050	-0.0
N2A0	0.51	0.78	0.89	108236	108233	-0.0	1145022	1145022	0.0
N2B0	0.50	0.96	0.88	34712	31972	-7.9	618698	618692	-0.0
N3A0	0.87	0.93	1.00	138685	109393	-21.1	830380	830730	0.0
N5A1	0.86	0.86	0.94	128719	97672	-24.1	335035	337240	0.7
N5A9	0.64	0.97	0.94	31051	31047	-0.0	128193	128195	0.0
N6A4	0.80	0.99	0.91	124721	123535	-1.0	327380	327671	0.1
N6A9	0.27	0.89	0.99	31311	31172	-0.4	240522	240599	0.0
Total				1091834	956844	-12.3	9580145	9604719	.2

Note: Welfare values are average yearly on period 2002-2013 scaled by market size. Δ stands for the change of welfare between after and before in percentage of initial welfare. The parameter ρ_{jm} is the one estimated from the supply model in Canada and used for counterfactual simulations.

Table 7.12: *Counterfactual Expenses, Profits on All Drugs when Canada as Price Ceiling*

	Expenses			Profits		
ATC4	Before	After	Δ (%)	Before	After	Δ (%)
A10C1	118145	118248	0.1	100914	101048	0.1
A2B2	284788	298546	4.8	154494	166240	7.6
B1B2	1366755	1371139	0.3	1317110	1319003	0.1
C10A1	186216	196756	5.7	101991	110023	7.9
C2A2	38062	38063	0.0	5699	5699	0.0
C7A0	148647	148697	0.0	32590	32639	0.1
C8A0	259058	259921	0.3	107268	109296	1.9
C9A0	66957	69790	4.2	20155	21663	7.5
C9C0	68047	71655	5.3	35648	38387	7.7
L1A0	244904	253235	3.4	103496	112307	8.5
L1B0	482675	479282	-0.7	214305	221685	3.4
L1C0	720750	753126	4.5	320143	338649	5.8
L1D0	192101	195651	1.8	75846	78384	3.3
L1X4	135841	149569	10.1	94154	107787	14.5
L1X9	160825	160989	0.1	77580	77794	0.3
L2B2	10886	12162	11.7	6970	8056	15.6
L2B3	20259	26822	32.4	15144	21106	39.4
L4X0	313040	378839	21.0	114726	180293	57.2
M1A1	28109	32044	14.0	3911	7189	83.8
M5B3	33507	33770	0.8	21752	22009	1.2
N1A1	558890	561233	0.4	362079	364754	0.7
N1A2	642266	642396	0.0	170936	171068	0.1
N1B1	93051	93285	0.3	25374	25599	0.9
N1B3	167484	167484	-0.0	29296	29296	0.0
N2A0	486180	486182	0.0	65131	65133	0.0
N2B0	84433	85358	1.1	13931	14791	6.2
N3A0	450060	460845	2.4	127309	137569	8.1
N5A1	1113479	1172218	5.3	596356	653992	9.7
N5A9	51146	51144	-0.0	6999	6999	0.0
N6A4	155712	155563	-0.1	75488	75542	0.1
N6A9	48988	49026	0.1	15027	15036	0.1
Total	8731260	8973041	2.7	4411821	4639034	5.1

Note: All values are average yearly on period 2002-2013, summing US and Canada. Δ stands for the change between after and before in percentage of initial value.

Table 7.13: *Counterfactual Expenses by ATC-4 with varying MFN rule (0, +33%, +50%) and Larger Reference Market (Canada as Price Ceiling)*

			ρ_{jm}			Canada			US		
ATC4	MFN	Share US market	On Patent	Branded Off	Generic	Before	After	Δ (%)	Before	After	Δ (%)
A2B2	0	0	0.55	0.90	0.87	14057	26529	88.7	270730	272016	0.5
A2B2	0	50	0.55	0.90	0.87	87651	156990	79.1	263927	271068	2.7
A2B2	0	100	0.55	0.90	0.87	185358	311647	68.1	268488	278951	3.9
A2B2	33	0	0.55	0.90	0.87	14057	23928	70.2	270730	271609	0.3
A2B2	50	0	0.55	0.90	0.87	14057	22349	59.0	270730	271328	0.2
B1B2	0	0	0.70			40084	78711	96.4	1326672	1292428	-2.6
B1B2	0	50	0.70			273470	462709	69.2	1324179	1152193	-13.0
B1B2	0	100	0.70			485702	767729	58.1	1176227	930594	-20.9
B1B2	33	0	0.70			40084	62512	56.0	1326889	1310894	-1.2
B1B2	50	0	0.70			38563	50214	30.2	1284627	1277971	-0.5
L1B0	0	0	0.64	0.50	1.00	33075	60786	83.8	449600	418495	-6.9
L1B0	0	50	0.64	0.50	1.00	27299	52851	93.6	481761	459276	-4.7
L1B0	0	100	0.64	0.50	1.00	42581	74518	75.0	365435	337062	-7.8
L1B0	33	0	0.64	0.50	1.00	31638	54254	71.5	426957	404204	-5.3
L1B0	50	0	0.64	0.50	1.00	29628	45343	53.0	396918	381692	-3.8
N1A1	0	0	0.45	0.57	1.00	15417	19358	25.6	543474	541875	-0.3
N1A1	0	50	0.45	0.57	1.00	220806	267795	21.3	543474	520339	-4.3
N1A1	0	100	0.45	0.57	1.00	441612	523748	18.6	543474	503817	-7.3
N1A1	33	0	0.45	0.57	1.00	15417	16602	7.7	543474	543058	-0.1
N1A1	50	0	0.45	0.57	1.00	15417	15634	1.4	543474	543459	-0.0
N1A2	0	0	1.00	1.00	0.92	14275	14395	0.8	627990	628001	0.0
N1A2	0	50	1.00	1.00	0.92	65445	66059	0.9	627990	628042	0.0
N1A2	0	100	1.00	1.00	0.92	130890	132107	0.9	627990	628091	0.0
N1A2	33	0	1.00	1.00	0.92	14275	14354	0.6	627990	627998	0.0
N1A2	50	0	1.00	1.00	0.92	14275	14308	0.2	627990	627994	0.0
N2A0	0	0	0.51	0.78	0.89	21736	21737	0.0	464444	464445	0.0
N2A0	0	50	0.51	0.78	0.89	108392	108398	0.0	464444	464446	0.0
N2A0	0	100	0.51	0.78	0.89	216785	216799	0.0	464444	464448	0.0
N2A0	33	0	0.51	0.78	0.89	21736	21737	0.0	464444	464445	0.0
N2A0	50	0	0.51	0.78	0.89	21736	21737	0.0	464444	464445	0.0
N3A0	0	0	0.87	0.93	1.00	11366	21739	91.3	438695	439107	0.1
N3A0	0	50	0.87	0.93	1.00	70808	154260	117.9	438695	441048	0.5
N3A0	0	100	0.87	0.93	1.00	141617	305398	115.7	438695	442809	0.9
N3A0	33	0	0.87	0.93	1.00	11366	19879	74.9	438695	438915	0.1
N3A0	50	0	0.87	0.93	1.00	11056	17249	56.0	432920	432997	0.0
N5A1	0	0	0.86	0.86	0.94	74422	138244	85.8	1039056	1033974	-0.5
N5A1	0	50	0.86	0.86	0.94	104691	197505	88.7	1039056	1031817	-0.7
N5A1	0	100	0.86	0.86	0.94	212643	399326	87.8	1064367	1049939	-1.4
N5A1	33	0	0.86	0.86	0.94	74422	125483	68.6	1039056	1035314	-0.4
N5A1	50	0	0.86	0.86	0.94	74422	114947	54.5	1039056	1036307	-0.3

Note: The column "MFN", which takes values 0, 33 and 50, refers to simulations in which pricing in the US is referenced with respect to Canadian prices plus a markup of 0%, +33%, *and* +50% *respectively. The column "Share US market", which takes values 0, 50 and 100, refers to simulations in which either the baseline Canadian market size (0), or a Canadian market size that is scaled up to represent* 50% *or being* 100% *of the US market, respectively.*

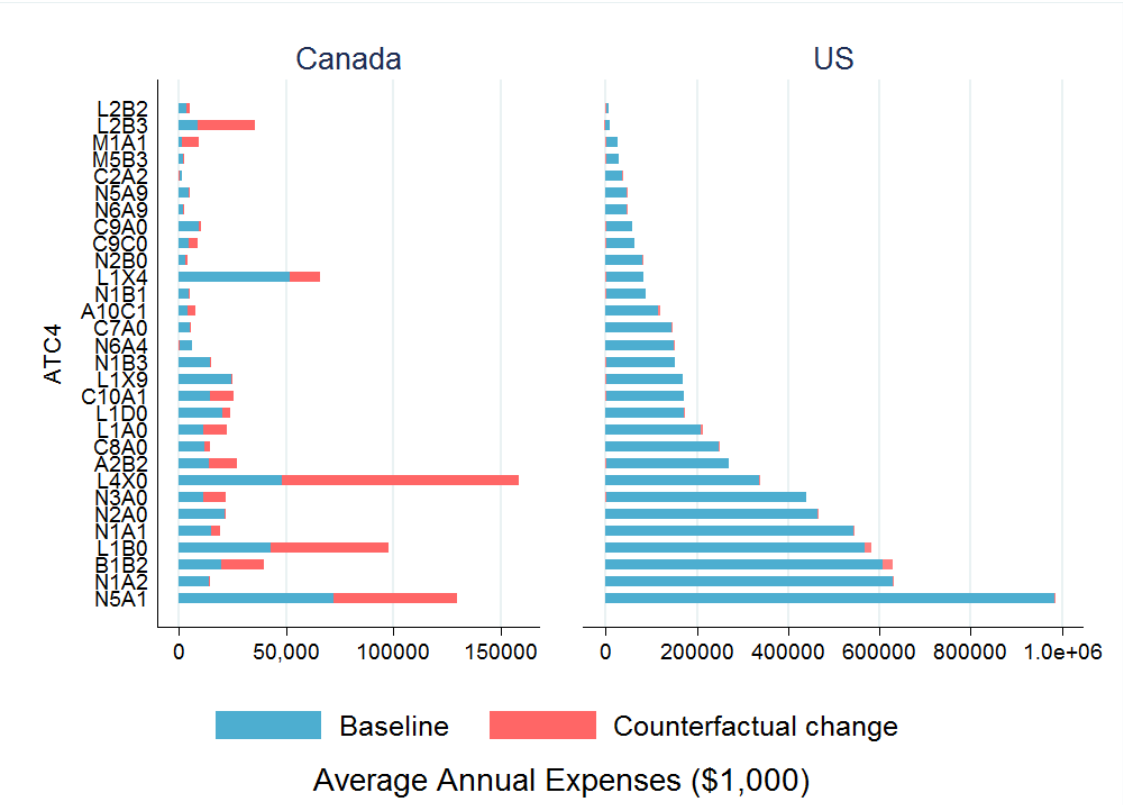
Table 7.14: *Counterfactual Prices when Canada as Price Ceiling*

	All				Patented				Branded Off				Generic			
	Before		After		Before		After		Before		After		Before		After	
ATC4	CA	US	CA	US	CA	US	CA	US	CA	US	CA	US	CA	US	CA	US
A10C1	12.05	37.13	21.83	36.51	12.05	37.13	21.83	36.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A2B2	0.76	2.44	1.76	2.42	0.83	2.75	2.46	2.71	0.67	3.43	1.27	3.43	0.59	0.63	0.73	0.63
B1B2	15.65	37.61	34.77	36.45	15.65	38.01	34.77	36.81	0.00	30.42	0.00	29.78	0.00	28.47	0.00	28.47
C10A1	1.32	2.23	2.36	2.21	1.77	3.43	3.86	3.34	1.99	2.32	5.32	2.28	0.49	0.50	0.66	0.50
C2A2	0.60	1.35	0.60	1.35	46.08	13.16	46.07	13.16	2.79	2.09	2.79	2.09	0.16	1.06	0.16	1.06
C7A0	0.22	0.87	0.22	0.87	0.30	3.37	0.31	3.37	1.11	2.14	1.12	2.14	0.18	0.60	0.18	0.60
C8A0	0.93	3.40	1.17	3.36	1.30	2.32	1.86	2.25	0.83	25.38	0.97	25.50	0.49	1.17	0.58	1.16
C9A0	0.52	0.51	0.67	0.52	0.68	1.68	1.13	1.57	0.51	1.70	0.52	1.70	0.26	0.30	0.28	0.30
C9C0	0.97	2.31	1.87	2.26	1.10	2.72	2.26	2.64	1.19	2.64	1.42	2.65	0.25	0.47	0.26	0.46
L1A0	17.69	135.17	37.44	134.39	24.69	229.55	77.20	226.60	1.53	109.79	1.79	109.11	14.51	48.55	33.95	48.56
L1B0	16.27	124.41	41.71	113.83	18.00	382.37	53.88	299.26	17.90	209.39	17.81	203.15	11.15	17.12	24.34	17.04
L1C0	270.87	443.02	343.38	445.82	468.30	999.85	781.79	953.96	110.03	350.44	108.43	350.99	86.50	73.89	92.17	73.82
L1D0	164.08	322.95	198.49	323.12	250.68	1350.26	685.96	1342.95	360.70	998.83	350.01	998.49	77.61	108.92	79.41	108.91
L1X4	66.23	112.85	120.27	112.42	66.35	112.77	123.04	112.33	65.16	0.00	67.65	0.00	25.55	146.05	25.56	146.05
L1X9	20.64	138.60	20.98	138.49	642.79	741.55	982.29	738.00	0.94	0.00	0.95	0.00	1.64	15.12	1.67	15.12
L2B2	2.19	10.08	2.87	10.24	10.43	30.28	35.99	29.09	1.45	9.63	1.67	9.66	0.69	1.31	0.75	1.31
L2B3	4.81	11.29	9.70	9.78	4.88	11.75	9.99	10.11	3.80	17.52	4.52	17.45	2.23	0.52	2.49	0.52
L4X0	3.07	23.46	12.67	23.25	3.01	18.79	12.93	18.57	0.75	5.92	0.79	5.91	5.29	59.29	12.01	59.32
M1A1	0.19	0.27	0.88	0.28	0.67	3.68	1.38	3.05	0.50	0.95	0.82	0.95	0.13	0.23	0.75	0.23
M5B3	2.11	18.17	2.64	18.08	2.43	27.81	3.81	27.59	3.21	19.98	3.89	20.04	1.40	2.49	1.43	2.49
N1A1	0.81	0.82	1.09	0.82	0.79	0.92	1.18	0.91	0.92	0.76	1.13	0.76	0.26	0.54	0.33	0.54
N1A2	5.00	9.03	5.11	9.03	11.73	76.79	16.59	76.72	5.43	18.96	5.53	18.96	4.53	5.96	4.59	5.96
N1B1	4.48	4.35	4.78	4.35	10.97	15.64	12.75	15.63	4.63	6.76	5.10	6.76	3.19	2.84	3.32	2.84
N1B3	0.92	1.11	0.92	1.11	6.68	23.42	6.68	23.42	1.04	3.90	1.04	3.90	0.39	0.85	0.39	0.85
N2A0	0.59	1.36	0.59	1.36	0.77	3.20	0.77	3.20	1.18	3.86	1.18	3.86	0.48	1.14	0.48	1.14
N2B0	0.31	0.53	0.40	0.53	0.56	14.59	0.58	14.59	0.34	1.34	0.42	1.34	0.30	0.39	0.39	0.39
N3A0	0.26	1.49	0.57	1.50	1.36	4.30	3.12	4.28	0.20	5.65	0.35	5.65	0.20	0.79	0.45	0.79
N5A1	1.77	9.09	4.20	9.03	1.82	10.36	8.63	10.25	3.09	4.92	4.71	4.93	0.43	3.43	0.65	3.44
N5A9	0.46	1.27	0.46	1.27	2.90	2.76	2.91	2.75	1.17	16.30	1.17	16.30	0.25	1.11	0.25	1.11
N6A4	0.48	1.61	0.53	1.61	1.35	3.61	3.32	3.60	1.44	4.22	1.45	4.22	0.28	0.48	0.29	0.48
N6A9	0.19	0.63	0.19	0.63	0.40	2.95	0.43	2.86	0.58	3.47	0.58	3.47	0.13	0.32	0.13	0.32

Note: Market shares weighted average price by ATC-4, country.

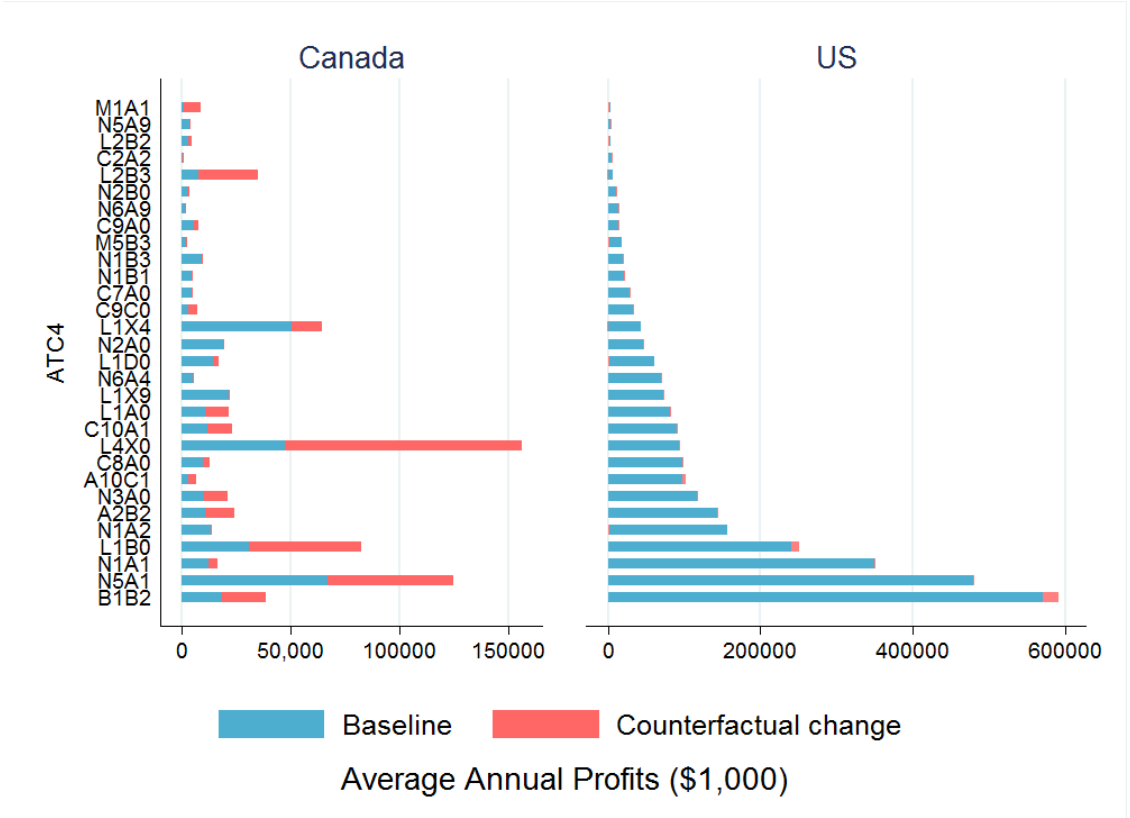
7.5.2 Counterfactuals with US as Price Floor for Canada

Figure 7.1: *Counterfactual Expenditure with US as Price Floor for Canada*



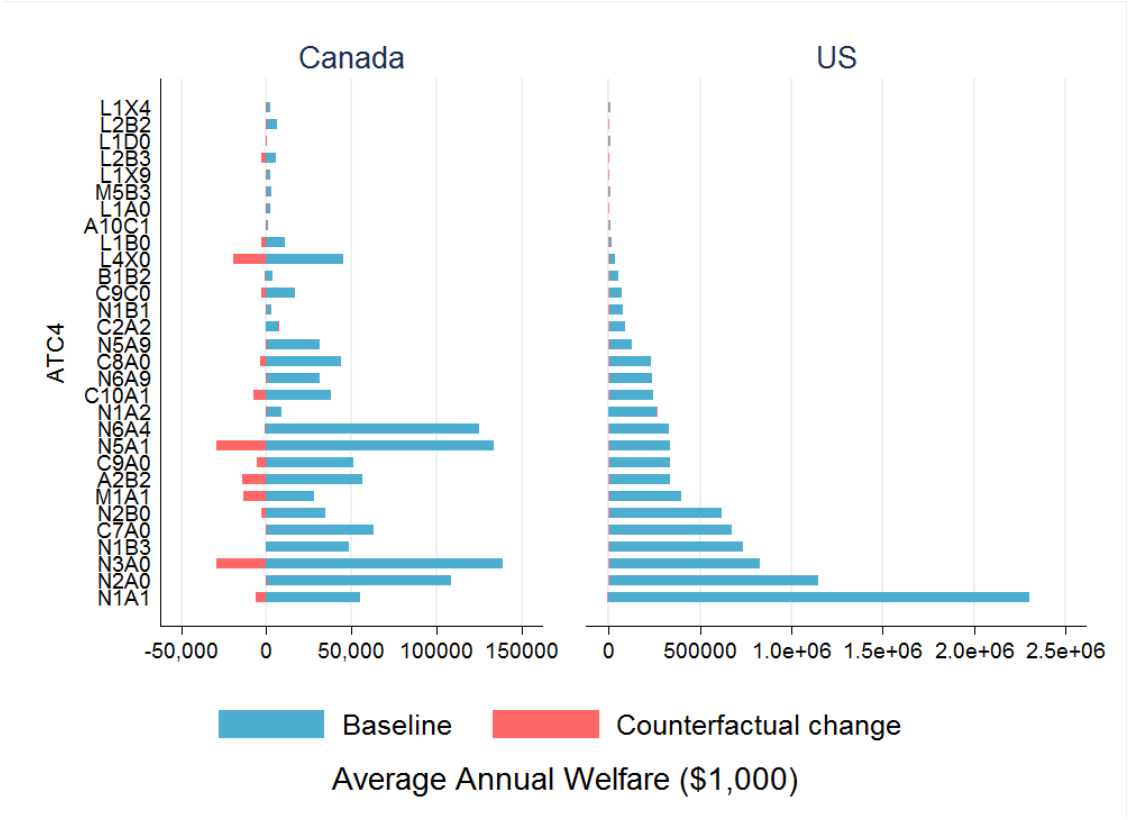
Note: Each blue bar indicates the average annual expenditure in each ATC-4 class in the baseline without reference pricing. The red bar indicates the change in average annual expenditure resulting from imposing reference pricing. A red bar to the right of the blue bar indicates that expenditure increased by the length of the red bar. A red bar to the left of the blue bar indicates that expenditure decreased by the length of the red bar.

Figure 7.2: *Counterfactual Profits on All Drugs with US as Price Floor for Canada*



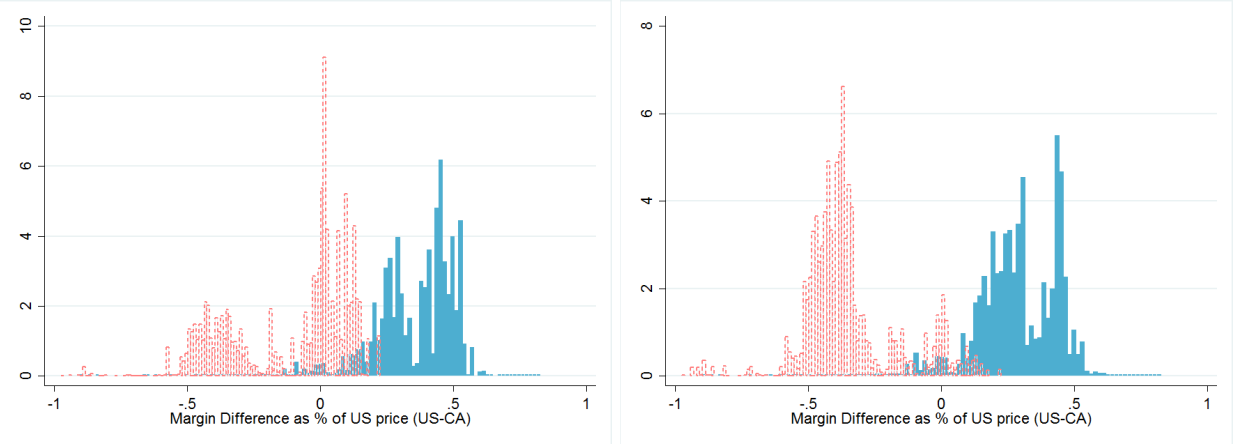
Note: Each blue bar indicates the average annual profits in each ATC-4 class in the baseline without reference pricing. The red bar indicates the change in average annual profits resulting from imposing reference pricing. A red bar to the right of the blue bar indicates that profits increased by the length of the red bar. A red bar to the left of the blue bar indicates that profits decreased by the length of the red bar.

Figure 7.3: *Counterfactual Welfare on All Drugs with US as Price Floor for Canada*



Note: Each blue bar indicates the average annual welfare in each ATC-4 class in the baseline without reference pricing. The red bar indicates the change in average annual welfare resulting from imposing reference pricing. A red bar to the right of the blue bar indicates that welfare increased by the length of the red bar. A red bar to the left of the blue bar indicates that welfare decreased by the length of the red bar.

Figure 7.4: *Counterfactual Margins Differences between US and Canada for on Patent Drugs with US as Price Floor for Canada*



Note: This distribution of margins differences by drug is weighted by the US quantities of the drug. This distribution is for the sample of on patent drugs present in both the US and Canada.

Table 7.15: *Counterfactual Expenses on All Drugs with US as Price Floor for Canada*

	ρ_{jm}			Canada			US		
ATC4	On Patent	Branded Off	Generic	Before	After	Δ (%)	Before	After	Δ (%)
A10C1	0.62			4161	7698	85.0	114540	118714	3.6
A2B2	0.55	0.90	0.87	14057	27056	92.5	270730	269312	-0.5
B1B2	0.70			20119	39542	96.5	608073	628156	3.3
C10A1	0.54	1.00	0.77	14549	25521	75.4	171667	169878	-1.0
C2A2	1.00	1.00	0.94	1484	1484	-0.0	36579	36579	0.0
C7A0	0.72	1.00	1.00	5103	5145	0.8	143544	143550	0.0
C8A0	0.56	0.89	0.86	11908	14919	25.3	247149	249531	1.0
C9A0	0.47	0.95	1.00	9728	10597	8.9	57249	56767	-0.8
C9C0	0.60	0.94	0.50	4588	8787	91.5	63460	63159	-0.5
L1A0	0.91	0.50	1.00	11325	22521	98.9	208639	212718	2.0
L1B0	0.64	0.50	1.00	42957	97837	127.8	567516	581168	2.4
L1D0	0.99	0.50	0.50	20424	23871	16.9	171677	171769	0.1
L1X4	1.00	0.50	0.50	51978	65938	26.9	83862	83630	-0.3
L1X9	0.92	0.50	0.57	24379	24659	1.1	169878	168734	-0.7
L2B2	0.83	0.94	0.61	3808	5096	33.8	7079	6919	-2.3
L2B3	0.70	0.79	0.58	8961	35604	297.3	10302	7627	-26.0
L4X0	0.95	0.91	1.00	48328	158193	227.3	335879	336534	0.2
M1A1	0.44	0.91	1.00	1644	9314	466.6	27173	26976	-0.7
M5B3	0.93	0.95	0.54	2294	2637	15.0	28980	28980	-0.0
N1A1	0.45	0.57	1.00	15417	19477	26.3	543474	545239	0.3
N1A2	1.00	1.00	0.92	14275	14395	0.8	627990	628001	0.0
N1B1	0.96	1.00	0.75	4917	5143	4.6	88133	88118	-0.0
N1B3	0.50	0.50	0.58	14496	14496	0.0	152988	152988	-0.0
N2A0	0.51	0.78	0.89	21736	21737	0.0	464444	464445	0.0
N2B0	0.50	0.96	0.88	3135	4058	29.4	81298	81300	0.0
N3A0	0.87	0.93	1.00	11366	21817	91.9	438695	438541	-0.0
N5A1	0.86	0.86	0.94	72065	129771	80.1	982970	983222	0.0
N5A9	0.64	0.97	0.94	4746	4746	0.0	46400	46402	0.0
N6A4	0.80	0.99	0.91	6183	6108	-1.2	149528	149531	0.0
N6A9	0.27	0.89	0.99	2245	2259	0.6	46742	46743	0.0
Total				472376	830426	75.7	6946639	6985231	.5

Note: Expenses are average yearly expenses in 1,000 US$ (from the period 2002-2013). Δ stands for the change in expenses between after and before in percentage of initial expenses. The parameter ρ_{jm} is the one estimated from the supply model in Canada and used for counterfactual simulations.

Table 7.16: *Counterfactual Profits on All Drugs with US as Price Floor for Canada*

	ρ_{jm}			Canada			US		
ATC4	On Patent	Branded Off	Generic	Before	After	Δ (%)	Before	After	Δ (%)
A10C1	0.62			3147	7058	124.2	98012	101680	3.7
A2B2	0.55	0.90	0.87	11212	24553	119.0	143282	143638	0.2
B1B2	0.70			18574	38591	107.8	571139	591894	3.6
C10A1	0.54	1.00	0.77	12037	23507	95.3	89953	91348	1.6
C2A2	1.00	1.00	0.94	1439	1439	-0.0	4260	4260	0.0
C7A0	0.72	1.00	1.00	4853	4906	1.1	27738	27742	0.0
C8A0	0.56	0.89	0.86	9790	13090	33.7	97479	98586	1.1
C9A0	0.47	0.95	1.00	5921	7911	33.6	14242	14253	0.1
C9C0	0.60	0.94	0.50	3139	7488	138.5	32509	33220	2.2
L1A0	0.91	0.50	1.00	10894	22071	102.6	80868	83130	2.8
L1B0	0.64	0.50	1.00	31298	82676	164.2	240837	251047	4.2
L1D0	0.99	0.50	0.50	14564	17224	18.3	61282	61180	-0.2
L1X4	1.00	0.50	0.50	50602	64534	27.5	43552	43253	-0.7
L1X9	0.92	0.50	0.57	22032	22439	1.8	73320	73467	0.2
L2B2	0.83	0.94	0.61	3468	4814	38.8	3503	3496	-0.2
L2B3	0.70	0.79	0.58	8140	35125	331.5	6206	5455	-12.1
L4X0	0.95	0.91	1.00	47554	156329	228.7	93069	93372	0.3
M1A1	0.44	0.91	1.00	1351	9012	566.8	2787	2741	-1.7
M5B3	0.93	0.95	0.54	1994	2335	17.1	17786	17785	-0.0
N1A1	0.45	0.57	1.00	12530	16897	34.9	349549	351515	0.6
N1A2	1.00	1.00	0.92	13656	13792	1.0	157280	157277	-0.0
N1B1	0.96	1.00	0.75	4678	4906	4.9	20696	20697	0.0
N1B3	0.50	0.50	0.58	9221	9221	0.0	20075	20075	0.0
N2A0	0.51	0.78	0.89	19276	19278	0.0	45855	45855	0.0
N2B0	0.50	0.96	0.88	2984	3842	28.8	10947	10948	0.0
N3A0	0.87	0.93	1.00	10688	21097	97.4	116621	116646	0.0
N5A1	0.86	0.86	0.94	67369	125091	85.7	478780	479551	0.2
N5A9	0.64	0.97	0.94	3851	3852	0.0	3148	3148	0.0
N6A4	0.80	0.99	0.91	5084	5372	5.7	70404	70433	0.0
N6A9	0.27	0.89	0.99	1878	1914	1.9	13149	13152	0.0
Total				413222	770361	86.40	2988326	3030844	1.4

Note: Profits are average yearly expenses in 1000 US$ (from the period 2002-2013). Δ stands for the change in profits between after and before in percentage of initial profits. The parameter ρ_{jm} is the one estimated from the supply model in Canada and used for counterfactual simulations.

Table 7.17: *Counterfactual Quantities on All Drugs with US as Price Floor for Canada*

	ρ_{jm}			Canada			US		
ATC4	On Patent	Branded Off	Generic	Before	After	Δ (%)	Before	After	Δ (%)
A10C1	0.62			349	152	-56.5	3304	3275	-0.9
A2B2	0.55	0.90	0.87	19362	15912	-17.8	113244	111835	-1.2
B1B2	0.70			1356	1068	-21.3	16922	16763	-0.9
C10A1	0.54	1.00	0.77	11349	10290	-9.3	79186	78021	-1.5
C2A2	1.00	1.00	0.94	2384	2384	0.0	26882	26882	-0.0
C7A0	0.72	1.00	1.00	23492	23400	-0.4	167276	167274	-0.0
C8A0	0.56	0.89	0.86	12760	12441	-2.5	73390	73001	-0.5
C9A0	0.47	0.95	1.00	18050	14289	-20.8	101961	101544	-0.4
C9C0	0.60	0.94	0.50	4801	4391	-8.5	27227	26413	-3.0
L1A0	0.91	0.50	1.00	680	572	-15.9	1521	1515	-0.4
L1B0	0.64	0.50	1.00	3855	2910	-24.5	4578	4543	-0.8
L1D0	0.99	0.50	0.50	123	116	-5.2	522	522	0.0
L1X4	1.00	0.50	0.50	785	556	-29.3	722	723	0.1
L1X9	0.92	0.50	0.57	799	796	-0.3	1039	1039	-0.0
L2B2	0.83	0.94	0.61	1791	1735	-3.1	677	673	-0.6
L2B3	0.70	0.79	0.58	1838	1012	-44.9	866	484	-44.1
L4X0	0.95	0.91	1.00	15038	10061	-33.1	13925	13868	-0.4
M1A1	0.44	0.91	1.00	8560	5585	-34.8	101620	101592	-0.0
M5B3	0.93	0.95	0.54	1096	993	-9.4	1614	1614	0.0
N1A1	0.45	0.57	1.00	19107	17729	-7.2	665328	664659	-0.1
N1A2	1.00	1.00	0.92	2865	2828	-1.3	69548	69548	0.0
N1B1	0.96	1.00	0.75	1096	1080	-1.5	20315	20314	-0.0
N1B3	0.50	0.50	0.58	16254	16254	0.0	145882	145882	-0.0
N2A0	0.51	0.78	0.89	36395	36395	-0.0	343829	343829	-0.0
N2B0	0.50	0.96	0.88	10159	9870	-2.8	153266	153266	-0.0
N3A0	0.87	0.93	1.00	42619	38975	-8.5	274813	274734	-0.0
N5A1	0.86	0.86	0.94	42666	34843	-18.3	112308	112259	-0.0
N5A9	0.64	0.97	0.94	9269	9267	-0.0	36694	36693	-0.0
N6A4	0.80	0.99	0.91	13805	12712	-7.9	89527	89520	-0.0
N6A9	0.27	0.89	0.99	11944	11888	-0.5	72854	72851	-0.0
Total				334645	300503	-10.2	2720842	2715136	-.2

Note: Quantity are average yearly standard units (on period 2002-2013). Δ stands for the change of quantity between after and before in percentage of initial quantity. The parameter ρ_{jm} is the one estimated from the supply model in Canada and used for counterfactual simulations.

Table 7.18: *Counterfactual Expenses on Patented Drugs with US as Price Floor for Canada*

				Canada			US		
		ρ_{jm}							
ATC4	*On Patent*	*Branded Off*	*Generic*	Before	After	Δ (%)	Before	After	Δ (%)
A10C1	0.62			4161	7698	85.0	114540	118714	3.6
A2B2	0.55	0.90	0.87	9018	18401	104.0	182955	181462	-0.8
B1B2	0.70			20119	39542	96.5	478597	495483	3.5
C10A1	0.54	1.00	0.77	11938	20641	72.9	139298	136735	-1.8
C2A2	1.00	1.00	0.94	761	761	-0.0	8330	8330	0.0
C7A0	0.72	1.00	1.00	311	320	2.9	27376	27375	-0.0
C8A0	0.56	0.89	0.86	7317	9002	23.0	47992	47297	-1.4
C9A0	0.47	0.95	1.00	6881	7511	9.1	23987	23454	-2.2
C9C0	0.60	0.94	0.50	4056	8191	102.0	61146	60823	-0.5
L1A0	0.91	0.50	1.00	9394	18724	99.3	152325	155363	2.0
L1B0	0.64	0.50	1.00	31685	70195	121.5	496763	508524	2.4
L1D0	0.99	0.50	0.50	8457	10107	19.5	65298	65493	0.3
L1X4	1.00	0.50	0.50	49887	63475	27.2	83505	83278	-0.3
L1X9	0.92	0.50	0.57	23506	23767	1.1	156957	155799	-0.7
L2B2	0.83	0.94	0.61	2638	3668	39.1	6229	6064	-2.6
L2B3	0.70	0.79	0.58	8706	35275	305.2	10127	7450	-26.4
L4X0	0.95	0.91	1.00	45041	143863	219.4	182953	183078	0.1
M1A1	0.44	0.91	1.00	450	2518	459.9	3195	2979	-6.8
M5B3	0.93	0.95	0.54	1077	1212	12.6	25993	25994	0.0
N1A1	0.45	0.57	1.00	6900	8686	25.9	350707	351757	0.3
N1A2	1.00	1.00	0.92	1192	1171	-1.8	70722	70740	0.0
N1B1	0.96	1.00	0.75	1456	1508	3.6	31019	30997	-0.1
N1B3	0.50	0.50	0.58	923	923	-0.0	1362	1362	-0.0
N2A0	0.51	0.78	0.89	346	346	-0.0	870	870	-0.0
N2B0	0.50	0.96	0.88	180	273	51.3	18975	18976	0.0
N3A0	0.87	0.93	1.00	3541	6527	84.3	195096	194883	-0.1
N5A1	0.86	0.86	0.94	29323	59479	102.8	865930	866139	0.0
N5A9	0.64	0.97	0.94	1716	1716	0.0	1153	1152	-0.1
N6A4	0.80	0.99	0.91	2473	2370	-4.2	113105	113095	-0.0
N6A9	0.27	0.89	0.99	341	344	0.8	4674	4668	-0.1
Total				293793	568212	93.40	3921179	3948336	.69

Note: Expenses are average yearly expenses in 1000 US$ (on period 2002-2013). Patented drugs only.

Table 7.19: *Counterfactual Prices by ATC-4 with US as Price Floor for Canada*

ATC4	ρ_{jm} On Patent	ρ_{jm} Branded Off	ρ_{jm} Generic	Price Change All drugs CA (%)	Price Change All drugs US (%)	Price Change Patented CA (%)	Price Change Patented US (%)	Price Change Branded Off CA (%)	Price Change Branded Off US (%)	Price Change Generic CA (%)	Price Change Generic US (%)
A10C1	0.62			328.3	5.2	328.3	5.2				
A2B2	0.55	0.90	0.87	138.8	0.6	209.4	1.2	92.1	0.0	24.2	0.1
B1B2	0.70			149.5	4.2	149.5	4.7		2.7		-0.0
C10A1	0.54	1.00	0.77	91.0	0.7	141.9	2.6	184.1	1.7	40.0	0.4
C2A2	1.00	1.00	0.94	-0.0	0.0	-0.0	0.0	0.0	0.0	-0.0	0.0
C7A0	0.72	1.00	1.00	1.5	0.0	3.3	0.1	0.5	-0.0	1.1	0.0
C8A0	0.56	0.89	0.86	29.3	1.5	49.3	3.6	18.4	-0.2	19.9	0.2
C9A0	0.47	0.95	1.00	34.3	-0.5	80.1	1.5	2.1	-0.0	8.3	0.0
C9C0	0.60	0.94	0.50	112.7	2.3	128.2	3.0	23.0	-0.2	1.8	0.5
L1A0	0.91	0.50	1.00	147.1	2.5	262.0	5.7	15.5	0.1	160.3	-0.0
L1B0	0.64	0.50	1.00	214.8	3.2	289.8	12.4	-1.4	0.0	164.9	-0.1
L1D0	0.99	0.50	0.50	21.0	0.0	174.1	-0.5	-3.0	-0.0	2.3	-0.0
L1X4	1.00	0.50	0.50	81.6	-0.4	85.4	-0.4	3.8		0.0	0.0
L1X9	0.92	0.50	0.57	1.5	-0.6	48.9	0.1	1.4		2.1	-0.0
L2B2	0.83	0.94	0.61	37.9	-2.7	320.5	0.5	16.9	0.2	11.1	-0.2
L2B3	0.70	0.79	0.58	612.1	29.2	648.0	33.1	24.4	0.1	15.5	0.0
L4X0	0.95	0.91	1.00	392.3	0.6	414.7	0.8	5.6	0.0	158.4	-0.0
M1A1	0.44	0.91	1.00	769.3	-0.7	607.0	6.0	186.8	0.0	936.3	-0.0
M5B3	0.93	0.95	0.54	22.4	-0.0	53.8	-0.0	21.3	0.0	2.4	0.0
N1A1	0.45	0.57	1.00	36.7	0.4	50.1	0.8	23.5	-0.0	26.2	-0.1
N1A2	1.00	1.00	0.92	2.3	0.0	41.4	-0.1	1.8	-0.0	1.4	0.0
N1B1	0.96	1.00	0.75	6.7	-0.0	16.4	0.1	10.1	-0.0	4.3	-0.0
N1B3	0.50	0.50	0.58	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
N2A0	0.51	0.78	0.89	0.0	0.0	0.1	0.0	-0.0	0.0	0.0	0.0
N2B0	0.50	0.96	0.88	29.0	0.0	4.5	0.0	22.8	0.0	30.3	0.0
N3A0	0.87	0.93	1.00	117.4	-0.0	132.8	0.2	79.6	0.0	133.3	-0.0
N5A1	0.86	0.86	0.94	121.3	0.1	372.1	0.1	47.8	-0.1	51.4	-0.0
N5A9	0.64	0.97	0.94	0.0	0.0	0.5	0.3	-0.0	-0.0	0.0	0.0
N6A4	0.80	0.99	0.91	9.5	0.0	149.6	0.1	0.5	0.0	0.4	-0.0
N6A9	0.27	0.89	0.99	1.2	0.0	6.7	0.5	-0.1	0.0	0.8	0.0

Note: Changes in % of initial price using market shares weighted average prices.

Table 7.20: *Counterfactual Prices of Drugs on Patent present in both US and Canada with US as Price Floor for Canada*

	Before		After			
	Canada	US	Canada		US	
ATC4	Price	Price	Price	Δ (%)	Price	Δ (%)
A10C1	12.14421	37.09733	61.24129	404.28	39.06341	5.30
A2B2	.8079825	2.675094	2.821949	249.26	2.70827	1.24
B1B2	15.36494	37.85803	41.56478	170.52	39.64621	4.72
C10A1	1.770697	3.82358	4.284205	141.95	3.982836	4.17
C2A2	54.75095	13.18811	54.72902	-0.04	13.18826	0.00
C7A0	1.244643	7.688396	2.185894	75.62	7.714972	0.35
C8A0	1.268361	2.297664	2.40667	89.75	2.385341	3.82
C9A0	.5887031	1.685948	2.012465	241.85	1.717792	1.89
C9C0	1.094559	2.528681	2.574439	135.20	2.621561	3.67
L1A0	25.97724	205.1478	95.36224	267.10	216.579	5.57
L1B0	17.3866	268.2582	97.04	458.13	306.8802	14.40
L1D0	292.0294	780.7533	1263.382	332.62	779.0521	-0.22
L1X4	66.59953	99.22975	125.893	89.03	98.87096	-0.36
L1X9	753.4308	886.57	1125.542	49.39	887.5515	0.11
L2B2	10.43049	32.88236	43.86275	320.52	33.14288	0.79
L2B3	4.865076	11.75005	39.00875	701.81	16.18691	37.76
L4X0	3.320533	10.59573	17.55219	428.60	10.66112	0.62
M1A1	.6708143	2.973108	6.520396	872.01	3.234343	8.79
M5B3	6.807281	16.13616	18.41846	170.57	16.13214	-0.02
N1A1	.662663	.919805	1.044167	57.57	.9271347	0.80
N1A2	12.79765	75.2755	31.65223	147.33	75.17893	-0.13
N1B1	13.03696	16.28716	16.27862	24.87	16.30099	0.08
N1B3						
N2A0	1.003563	3.317234	3.382701	237.07	3.317749	0.02
N2B0						
N3A0	1.384019	3.735585	3.464821	150.34	3.752379	0.45
N5A1	1.869504	9.782676	9.571216	411.97	9.7985	0.16
N5A9	.8207119	1.356838	1.388645	69.20	1.396926	2.95
N6A4	1.334195	3.653124	3.710609	178.12	3.656124	0.08
N6A9	.6356424	3.21982	2.009834	216.19	3.244288	0.76

Note: Market shares weighted average price of patented drugs by ATC-4, country for drugs present in both only. Percentage changes are changes with respect to the initial situation.

Table 7.21: *Counterfactual Consumer Welfare on All Drugs with US as Price Floor for Canada*

	ρ_{jm}			Canada			US		
ATC4	On Patent	Branded Off	Generic	Before	After	Δ (%)	Before	After	Δ (%)
A10C1	0.62			885	820	-7.3	11159	10912	-2.2
A2B2	0.55	0.90	0.87	56646	42488	-25.0	337119	335034	-0.6
B1B2	0.70			3914	2712	-30.7	55450	53879	-2.8
C10A1	0.54	1.00	0.77	37661	29862	-20.7	242072	238483	-1.5
C2A2	1.00	1.00	0.94	7111	7112	0.0	88937	88936	-0.0
C7A0	0.72	1.00	1.00	62951	62608	-0.5	675640	675626	-0.0
C8A0	0.56	0.89	0.86	44044	40615	-7.8	230677	229045	-0.7
C9A0	0.47	0.95	1.00	51194	45660	-10.8	335249	334683	-0.2
C9C0	0.60	0.94	0.50	16875	13793	-18.3	72193	70600	-2.2
L1A0	0.91	0.50	1.00	2092	1570	-24.9	5245	5204	-0.8
L1B0	0.64	0.50	1.00	10952	8058	-26.4	15958	15786	-1.1
L1D0	0.99	0.50	0.50	363	336	-7.5	2161	2162	0.0
L1X4	1.00	0.50	0.50	2126	1725	-18.9	2109	2116	0.3
L1X9	0.92	0.50	0.57	2486	2467	-0.8	3771	3769	-0.1
L2B2	0.83	0.94	0.61	6150	5665	-7.9	2158	2149	-0.4
L2B3	0.70	0.79	0.58	5427	2814	-48.1	2336	1665	-28.7
L4X0	0.95	0.91	1.00	45075	25378	-43.7	35499	35382	-0.3
M1A1	0.44	0.91	1.00	27881	14616	-47.6	397633	397520	-0.0
M5B3	0.93	0.95	0.54	2917	2656	-9.0	5131	5131	0.0
N1A1	0.45	0.57	1.00	55089	48904	-11.2	2307142	2299762	-0.3
N1A2	1.00	1.00	0.92	9216	9144	-0.8	260259	260260	0.0
N1B1	0.96	1.00	0.75	2969	2897	-2.4	76524	76521	-0.0
N1B3	0.50	0.50	0.58	48316	48316	0.0	736051	736050	-0.0
N2A0	0.51	0.78	0.89	108236	108233	-0.0	1145022	1145022	-0.0
N2B0	0.50	0.96	0.88	34712	31972	-7.9	618698	618692	-0.0
N3A0	0.87	0.93	1.00	138685	109231	-21.2	830380	830237	-0.0
N5A1	0.86	0.86	0.94	133543	104407	-21.8	333726	333418	-0.1
N5A9	0.64	0.97	0.94	31051	31046	-0.0	128193	128192	-0.0
N6A4	0.80	0.99	0.91	124721	123527	-1.0	327380	327334	-0.0
N6A9	0.27	0.89	0.99	31311	31166	-0.5	240522	240506	-0.0
Total				1104596	959797	-13.1	9524394	9504077	-.2

Note: Welfare values are average yearly on period 2002-2013 scaled by market size. Δ stands for the change of welfare between after and before in percentage of initial welfare. The parameter ρ_{jm} is the one estimated from the supply model in Canada and used for counterfactual simulations.

Table 7.22: *Counterfactual Expenses, Profits and Consumer Welfare Global Changes on All Drugs when US as Price Floor for Canada*

	Expenses			Profits		
ATC4	Before	After	Δ (%)	Before	After	Δ (%)
A10C1	118701	126412	6.5	101159	108738	7.5
A2B2	284788	296368	4.1	154494	168190	8.9
B1B2	628192	667698	6.3	589713	630485	6.9
C10A1	186216	195399	4.9	101991	114855	12.6
C2A2	38062	38063	0.0	5699	5699	0.0
C7A0	148647	148695	0.0	32590	32648	0.2
C8A0	259058	264450	2.1	107268	111676	4.1
C9A0	66978	67364	0.6	20164	22164	9.9
C9C0	68047	71946	5.7	35648	40708	14.2
L1A0	219964	235239	6.9	91762	105201	14.6
L1B0	610474	679005	11.2	272135	333723	22.6
L1D0	192101	195639	1.8	75846	78404	3.4
L1X4	135841	149569	10.1	94154	107787	14.5
L1X9	194257	193392	-0.4	95351	95906	0.6
L2B2	10886	12016	10.4	6970	8310	19.2
L2B3	19263	43231	124.4	14346	40579	182.9
L4X0	384207	494727	28.8	140623	249700	77.6
M1A1	28816	36290	25.9	4139	11752	183.9
M5B3	31274	31617	1.1	19780	20121	1.7
N1A1	558890	564717	1.0	362079	368412	1.7
N1A2	642266	642396	0.0	170936	171068	0.1
N1B1	93051	93261	0.2	25374	25602	0.9
N1B3	167484	167484	-0.0	29296	29296	0.0
N2A0	486180	486182	0.0	65131	65133	0.0
N2B0	84433	85358	1.1	13931	14791	6.2
N3A0	450060	460358	2.3	127309	137743	8.2
N5A1	1055035	1112993	5.5	546149	604642	10.7
N5A9	51146	51148	0.0	6999	7001	0.0
N6A4	155712	155639	-0.0	75488	75805	0.4
N6A9	48988	49002	0.0	15027	15067	0.3
Total	7419016	7815658	5.3	3401549	3801205	11.7

Note: All values are average yearly on period 2002-2013, summing US and Canada. Δ stands for the change between after and before in percentage of initial value.

Table 7.23: *Counterfactual Prices with US as Price Floor for Canada*

	All				Patented				Branded Off				Generic			
	Before		After		Before		After		Before		After		Before		After	
ATC4	CA	US	CA	US	CA	US	CA	US	CA	US	CA	US	CA	US	CA	US
A10C1	12.05	37.27	51.61	39.22	12.05	37.27	51.61	39.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A2B2	0.76	2.44	1.81	2.45	0.83	2.75	2.56	2.78	0.67	3.43	1.30	3.43	0.59	0.63	0.74	0.64
B1B2	15.14	36.08	37.79	37.60	15.14	37.86	37.79	39.65	0.00	30.42	0.00	31.25	0.00	28.47	0.00	28.47
C10A1	1.32	2.23	2.53	2.24	1.77	3.43	4.28	3.52	1.99	2.32	5.67	2.36	0.49	0.50	0.68	0.50
C2A2	0.60	1.35	0.60	1.35	46.08	13.16	46.06	13.16	2.79	2.09	2.79	2.09	0.16	1.06	0.16	1.06
C7A0	0.22	0.87	0.22	0.87	0.30	3.37	0.31	3.37	1.11	2.14	1.12	2.14	0.18	0.60	0.18	0.60
C8A0	0.93	3.40	1.20	3.45	1.30	2.32	1.94	2.40	0.83	25.38	0.98	25.33	0.49	1.17	0.59	1.17
C9A0	0.52	0.51	0.70	0.51	0.68	1.68	1.22	1.71	0.51	1.70	0.52	1.70	0.26	0.30	0.29	0.30
C9C0	0.97	2.31	2.06	2.36	1.10	2.72	2.52	2.80	1.19	2.64	1.47	2.63	0.25	0.47	0.26	0.47
L1A0	18.64	145.03	46.07	148.60	25.26	248.29	91.44	262.43	1.52	105.28	1.76	105.42	15.51	57.18	40.36	57.18
L1B0	16.21	127.49	51.05	131.58	17.50	401.51	68.22	451.30	28.88	223.27	28.49	223.35	11.06	16.72	29.30	16.70
L1D0	164.08	322.95	198.53	323.10	250.68	1350.26	687.10	1344.01	360.70	998.83	350.01	998.54	77.61	108.92	79.41	108.91
L1X4	66.23	112.85	120.26	112.42	66.35	112.77	123.04	112.33	65.16	0.00	67.65	0.00	25.55	146.05	25.56	146.05
L1X9	25.11	159.47	25.49	158.48	749.23	866.80	1115.65	867.61	0.95	0.00	0.96	0.00	1.56	15.22	1.59	15.22
L2B2	2.19	10.08	3.01	9.81	10.43	30.28	43.86	30.42	1.45	9.63	1.69	9.65	0.69	1.31	0.76	1.31
L2B3	4.80	11.34	34.18	14.66	4.88	11.83	36.49	15.75	3.80	17.52	4.72	17.54	2.23	0.52	2.58	0.52
L4X0	3.22	23.88	15.87	24.03	3.13	18.62	16.10	18.78	0.76	5.84	0.80	5.85	6.01	61.97	15.53	61.95
M1A1	0.19	0.28	1.67	0.27	0.68	3.61	4.77	3.83	0.50	0.94	1.45	0.94	0.13	0.22	1.31	0.22
M5B3	2.17	18.79	2.65	18.79	2.63	30.08	4.05	30.08	3.21	21.10	3.89	21.10	1.40	2.46	1.43	2.46
N1A1	0.81	0.82	1.10	0.82	0.79	0.92	1.19	0.93	0.92	0.76	1.14	0.76	0.26	0.54	0.33	0.54
N1A2	5.00	9.03	5.11	9.03	11.73	76.79	16.59	76.72	5.43	18.96	5.53	18.96	4.53	5.96	4.59	5.96
N1B1	4.48	4.35	4.78	4.34	10.97	15.64	12.76	15.65	4.63	6.76	5.10	6.76	3.19	2.84	3.32	2.84
N1B3	0.92	1.11	0.92	1.11	6.68	23.42	6.68	23.42	1.04	3.90	1.04	3.90	0.39	0.85	0.39	0.85
N2A0	0.59	1.36	0.59	1.36	0.77	3.20	0.77	3.20	1.18	3.86	1.18	3.86	0.48	1.14	0.48	1.14
N2B0	0.31	0.53	0.40	0.53	0.56	14.59	0.58	14.59	0.34	1.34	0.42	1.34	0.30	0.39	0.39	0.39
N3A0	0.26	1.49	0.58	1.49	1.36	4.30	3.17	4.31	0.20	5.65	0.35	5.65	0.20	0.79	0.46	0.79
N5A1	1.68	8.76	3.72	8.76	1.92	10.88	9.06	10.89	3.13	9.60	4.62	9.59	0.40	3.16	0.61	3.16
N5A9	0.46	1.27	0.46	1.27	2.90	2.76	2.91	2.76	1.17	16.30	1.17	16.30	0.25	1.11	0.25	1.11
N6A4	0.48	1.61	0.53	1.61	1.35	3.61	3.36	3.62	1.44	4.22	1.45	4.22	0.28	0.48	0.29	0.48
N6A9	0.19	0.63	0.19	0.63	0.40	2.95	0.43	2.97	0.58	3.47	0.58	3.47	0.13	0.32	0.13	0.32

Note: Market shares weighted average price by ATC-4, country.

Table 7.24: *Counterfactual Expenses by ATC-4 with varying MFN rule (0, +33%, +50%) and Larger Reference Market (with US as Price Floor for Canada)*

			ρ_{jm}			Canada			US		
ATC4	MFN	US Share market	On Patent	Branded Off	Generic	Before	After	Δ (%)	Before	After	Δ (%)
A2B2	0	0	0.55	0.90	0.87	14057	27056	92.5	270730	269312	-0.5
A2B2	0	50	0.55	0.90	0.87	87651	397239	353.2	265525	226660	-14.6
A2B2	0	100	0.55	0.90	0.87	185358	860600	364.3	270730	218992	-19.1
A2B2	33	0	0.55	0.90	0.87	14057	24039	71.0	270730	270848	0.0
A2B2	50	0	0.55	0.90	0.87	14057	22464	59.8	270730	271066	0.1
B1B2	0	0	0.70			20119	39542	96.5	608073	628156	3.3
B1B2	0	50	0.70			119343	279338	134.1	608073	700171	15.1
B1B2	0	100	0.70			258228	667346	158.4	669466	828933	23.8
B1B2	33	0	0.70			20119	29369	46.0	608073	599771	-1.4
B1B2	50	0	0.70			20119	26030	29.4	608073	620713	2.1
C8A0	0	0	0.56	0.89	0.86	11908	14919	25.3	247149	249531	1.0
C8A0	0	50	0.56	0.89	0.86	37979	49531	30.4	247149	254319	2.9
C8A0	0	100	0.56	0.89	0.86	75959	104262	37.3	247149	260711	5.5
C8A0	33	0	0.56	0.89	0.86	11908	12861	8.0	247149	247943	0.3
C8A0	50	0	0.56	0.89	0.86	11908	12007	0.8	247149	247079	-0.0
N1A1	0	0	0.45	0.57	1.00	15417	19477	26.3	543474	545239	0.3
N1A1	0	50	0.45	0.57	1.00	220806	290984	31.8	543474	569227	4.7
N1A1	0	100	0.45	0.57	1.00	441612	616921	39.7	543474	578469	6.4
N1A1	33	0	0.45	0.57	1.00	15417	16624	7.8	543474	543661	0.0
N1A1	50	0	0.45	0.57	1.00	15417	15631	1.4	543474	543431	-0.0
N1A2	0	0	1.00	1.00	0.92	14275	14395	0.8	627990	628001	0.0
N1A2	0	50	1.00	1.00	0.92	65445	66059	0.9	627990	628042	0.0
N1A2	0	100	1.00	1.00	0.92	130890	132107	0.9	627990	628091	0.0
N1A2	33	0	1.00	1.00	0.92	14275	14345	0.5	627990	628235	0.0
N1A2	50	0	1.00	1.00	0.92	14275	14306	0.2	627990	628182	0.0
N2A0	0	0	0.51	0.78	0.89	21736	21737	0.0	464444	464445	0.0
N2A0	0	50	0.51	0.78	0.89	108392	108398	0.0	464444	464444	-0.0
N2A0	0	100	0.51	0.78	0.89	216785	216796	0.0	464444	464444	-0.0
N2A0	33	0	0.51	0.78	0.89	21736	21737	0.0	464444	464445	0.0
N2A0	50	0	0.51	0.78	0.89	21736	21737	0.0	464444	464445	0.0
N3A0	0	0	0.87	0.93	1.00	11366	21817	91.9	438695	438541	-0.0
N3A0	0	50	0.87	0.93	1.00	70808	158094	123.3	438695	437694	-0.2
N3A0	0	100	0.87	0.93	1.00	141617	318854	125.2	438695	436773	-0.4
N3A0	33	0	0.87	0.93	1.00	11366	19574	72.2	438695	440600	0.4
N3A0	50	0	0.87	0.93	1.00	11056	17313	56.6	432920	432944	0.0
N5A1	0	0	0.86	0.86	0.94	74422	138838	86.6	1039056	1039390	0.0
N5A1	0	50	0.86	0.86	0.94	104691	198866	90.0	1039056	1039544	0.0
N5A1	0	100	0.86	0.86	0.94	212643	404678	90.3	1064367	1065295	0.1
N5A1	33	0	0.86	0.86	0.94	74422	123588	66.1	1039056	1019630	-1.9
N5A1	50	0	0.86	0.86	0.94	74422	111290	49.5	1039056	994674	-4.3