Environmental Regulation, Market Power, and Price Discrimination in the Agricultural Chemical Industry

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Abstract

Chemical companies generally support environmental regulatory segregation Canadian and U.S. agricultural chemical markets, apparently because it enables them to practice third order price discrimination. This study provides new cross section evidence that suggests price discrimination is practiced. We examine the potential implications chemical market desegregation for agricultural chemical prices, farmer welfare, and consumer welfare.

Key words: price discrimination, agricultural chemicals, economic welfare

1. Introduction

Pesticides and herbicides control weeds and prevent or mitigate pest infestations that may otherwise severely affect crop yields and their use in American agriculture is widespread. Even in semi-arid regions such as the Northern Great Plains farmers spend between $5 and $10 an acre on them (Goodwin and Smith). This is a substantial amount of funds for dry land farms, representing roughly between 8 and 16 percent of per acre variable costs for crops such as wheat and barley and in absolute terms chemical expenditures range from $10,000 to $20,000 for many family operations that mainly rely on farming for their incomes.[1] In wetter areas of the country and on irrigated land, per acre agricultural chemical expenditures are much higher. For example, farms in the Midwest may spend between $20 and $40 dollars per acre on agricultural chemicals. Agricultural chemical prices therefore matter to most farmers as do government programs that affect those prices. Given that agricultural chemical prices also affect supply functions and prices for agricultural commodities, food processors and consumers also have a stake in the agricultural chemical pricing game.

Agricultural chemicals are in fact subject to multiple regulations implemented by different government agencies, each with their own policy remits and agency objectives, many of which affect market structures and prices. In the case of agricultural chemicals, the interface of different regulations and proposed regulatory initiatives has implications

[1] In Montana, Western North Dakota, and Western Kansas, many dry land operations that generate between $40,000 and $80,000 a year in net revenues consist of between 3,000 and 5,000 acres, of which about 60 percent are cropped in any given year and 40 percent are left fallow. Per acre agricultural chemical costs of $5 to $10, total agricultural chemical expenditures are relatively substantial proportions of total per acre variable costs for Montana dryland farms that range of $50 to $70 per acre (Johnson et al.).

for the potential for agricultural chemical producers to practice third order price discrimination in markets segregated by differential regulation.[2]

Third order price discrimination occurs when consumers in segregated markets are charged different prices for the same product even though there are no differences in firm costs of supplying each market. The prices differences simply derive from differences in own price demand elasticities that are exploited by the seller to maximize profits.

Recently, congressional delegations from the Northern Great Plains have proposed that chemicals with identical or very similar active ingredients be freely traded between Canada and the United States under a regulatory harmonization initiative. The U.S. agricultural chemical industry, a subset of the U.S. chemical industry, has strongly opposed Congressional harmonization initiatives on several grounds, including the claim that in fact some chemical prices are lower in the United States and that trade liberalization would yield no net gain for U.S. producers. A key member of the U.S. House Committee, with some prompting from the chemical industry, also expressed concerns about trade liberalization between Canada and the United States through harmonized pesticide registration policies because of concerns about implications for the value of patent rights and incentives for private investments in pesticide R&D.

Thus, this paper explores the following issues. What are the sources of market segmentation between Canada and the United States agricultural chemicals? Are chemical manufacturers exploiting market segmentation and to what extent? And what

[2] First order price discrimination occurs when the seller is able to perfectly price discriminate and charge each consumer their exact willingness to pay for the product. Second order price discrimination occurs when price differences can be completely accounted for by differences in marginal costs of supplying each market. Such price differences may arise because of variations in transportation and other costs of supplying different customers and often result from practices such as quantity discounts.

would regulatory harmonization and trade liberalization proposals imply for the future of agricultural chemical prices and agricultural chemical R&D? To set the scene, we begin with a brief review of the welfare implications of third order price discrimination.

2. Third Order Price Discrimination

A seller may offer a commodity for different prices in different markets when arbitrage between consumers in the two markets is infeasible. Barriers to trade may be inherent in the nature of the commodity, as is the case with much medical care. For example, one person cannot resell their hernia operation to another person. Often barriers arise because of spatial separation. On that basis, for example, the Canadian Wheat Board (CWB) frequently claims it is able to charge higher prices to Japanese buyers of hard red spring wheat than to buyers in other markets on that basis.[3] However, differences in regulatory regimes and other government policies also segment markets that are geographically proximate.

If two or more markets are segmented, then the seller will determine sales in each market by equating market specific marginal costs with market specific marginal revenues. As is well known, the result is that the commodity's price will be highest in the market in which the absolute value of the own price elasticity of demand is lowest, and lowest in the market in which the absolute value of the own price demand elasticity is highest (Varian).

[3] This is probably an unrealistic claim. Carter et al., for example, have noted that the CWB tends to "over-deliver" on quality attributes and credit terms. In addition, they also noted that prices received by Canadian wheat farmers are very similar and not systematically higher than prices received by U.S. producers at comparable locations, even though those U.S. producers typically face higher freight rates. The only studies that provide empirical estimates that validate the CWB's claim (Kraft et al and Lavoie) rely on questionable confidential data constructed and supplied by the CWBV itself.

The welfare consequences of price discrimination, relative to the benchmark of a single price charged by a monopolist when marginal costs are constant over the relevant range of the firm's cost function, are as follows. In a two market world, when markets are segmented and price discrimination is introduced, in terms of economic surplus, consumers in the high price market are worse off while consumers in the low price market are better off because price rises in the market with the relatively inelastic demand curve and falls in the market with the more elastic demand curve. Producer welfare increases and total economic welfare also increases.

In the two market case, whether or not buyers as a whole are better or worse off under price discrimination depends on the shapes of the compensated demand curves. However, if market segmentation is complete (in that each buyer is segmented from all other consumers) and the firm practices first order price discrimination, then consumer surplus falls to zero as the firm captures all rents and buyers as a whole are clearly worse off. In addition, third order price discrimination will generally increase aggregate economic welfare relative to a monopoly single-price equilibrium when economic welfare is measured by the simple sum of producer and consumer surplus. The monopoly producer gains as do buyers in the low-price market, but buyers in the high-price market will lose. On a net basis, buyer welfare losses in the high-price market may or may not more than offset the gains in the low-price market and so buyers as a whole could be either worse off or better off.[4]

[4] See, for example, Varian (1989), and more recently Clerides (2004), Stole (2001), and Yoshida (2000). The aggregate effect on consumer welfare depends on the shape of the compensated demand curves in the two market case, but as market segmentation increases so does the likelihood of reductions in aggregate consumer welfare. In the limit, under perfect or first-order price discrimination, all economic welfare accrues to the monopolist.

In the context of the market for any specific agricultural chemical, whether U.S. farmers will be better off under an integrated single market or market segmentation turns on whether the United States is the high priced market under market segmentation. This is an empirical question. Whether a harmonization regulation that reintegrates the U.S. and Canadian agricultural chemical markets is beneficial also depends on whether the U.S. is the high price market for agricultural chemicals in general, and if not, for which agricultural chemicals it is the high priced market, for which it is the low price market, and by how much the prices of the different chemicals would change under harmonization..

3. Sources of Agricultural Chemical Market Segmentation between Canada and the United States

Many of the markets for agricultural chemicals in Canada and the United States are spatially adjacent. For example, some farmers on one side of the Alberta-Montana border (the 49th Parallel) are literally a stone's throw away from farmers on the other side of the border but cannot legally purchase the same agricultural chemical from the same chemical dealer. Absent regulatory barriers, arbitrage would almost surely guarantee that prices in those spatially adjacent markets would exhibit very similar patterns and on average be about the same.[5] These markets are segregated because of regulation.

[5] It is well known that prices for homogeneous products are frequently disperse among sellers within well-defined competitive markets. Sorenson, for example, reported substantial price variation for identical drugs among pharmacies in two small towns in up-state New York where each pharmacy was required to post its prices for over 150 commonly used pharmaceuticals. Search models in which information is costly provide explanations of such phenomena (see, for example, Stigler, Salop and Stiglitz, Carlson and McAfee, and McMillan and Morgan). However, they do not imply that average prices from randomly selected samples drawn from the same population in a common market should be statistically significantly different.

In Canada, at the federal level, pesticide use is regulated by the Pest Management Regulatory Agency (PMRA) established under Canada's 1985 Pest Control Products Act. All pesticides used in Canada must be registered by the PMRA. The terms and scope of use are determined by the Canadian registration and sold under a PMRA-approved label that describes the product and its specific approved uses. Pesticides registered for use in the United States and sold under a U.S. label cannot be used legally in Canada even if its active ingredients are identical to one that has received a Canadian label. Similarly, pesticide use in the United States is regulated under the provisions of the 1947 Federal Insecticide, Fungicide, and Rodenticide Act, (FIFRA), as variously amended, and each agricultural chemical is sold under an EPA-approved label. Thus a pesticide registered and sold for use in Canada cannot legally be used in the United States even if its chemical formulation is identical to that of a product that is registered and sold for use in the United States.[6] Thus, the two countries' regulatory processes prevent legal arbitrage that would otherwise erode price differences. Price differences for the same agricultural chemicals have therefore persisted even between components of the markets that are spatially adjacent.

These price differences have been economically important. In 2000, for example, a past president of the Montana Grain Growers Association was found guilty of illegally conspiring to obtain Roundup from Canada and sell it to other farmers in Montana and

[6] Within the Unite States, under the provisions of FIFRA, individual states may impose stricter (but not weaker) controls over the use of specific pesticides than those required by the EPA and may prohibit the use of certain chemicals even though EPA has approved their use. In Canada, registration of a herbicide is either provided for the whole country or for one or more of three regions - the Prairie region (Alberta, Manitoba, Saskatchewan and the Peace River in British Columbia), the Atlantic Region (consisting of the maritime provinces), and the third region consisting of Ontario, Quebec and the rest of British Columbia.

adjacent states.[7] Moreover, price differences in the U.S. and Canadian markets have also led agricultural commodity organizations on both sides of the border to seek legislation that would "harmonize" U.S. and Canadian pesticide use regulations.

The U.S. initiative, embodied in Senate Bill 1406, was introduced in 2003 and cosponsored by Senators Dorgan and Conrad of North Dakota, Daschle and Johnson of South Dakota, and Burns and Baucus of Montana. The Bill would amend FIFRA to permit the EPA Administrator to register a Canadian pesticide with identical active ingredients and similar (though not necessarily identical) formulations to a pesticide already approved by EPA for use. In Congressional hearings in June of 2004, Mr. Jay Vroom, the president of CropLife America, the trade association representing manufacturers, distributors and formulators of agricultural chemicals, testified against the bill.

If, in fact, chemical manufacturers are concerned about losing opportunities for price discrimination, the industry's position vis a vis the legislation is hardly surprising. In addition to several other concerns,[8] the industry's representative claimed that no legislation was needed because Great Plains producers spent less on pesticides than did Canadian producers. This, of course, was not an "apples to apples" comparison. Canada includes many agricultural regions with much higher rainfall and much more severe pesticide problems than the semi-arid region of the Northern Great Plains, where dryland

[7] Prior to 2002, when Monsanato's U.S. patent on Roundup was still active, using surveys of agricultural chemical dealers, McEwan and Daley (1997), Carlson *et. al* (1999), and Freshwater (2003) reported that the product was substantially cheaper in Manitoba than in North Dakota. In 2000, Larry Johnson, a farmer and past president of the Montana Grain Growers Association, was found guilty of over 30 federal counts of conspiring illegally to sell the Canadian registered version of the product in the United States (*The Great Falls Tribune*, February, 2000).

[8] One of the industry representative's more profound assertions was that U.S. producers would be confused by Canadian chemical labels because the same information was provided in both English and French, although English speaking Canadians seemed to cope with the challenge quite well.

farmers are spending $5 to $10 per acre on pest control (Smith and Goodwin), compared to $15 or $40 per acre for corn producers in Iowa or Indiana or, for that matter, the Canadian province of Ontario. In early October of 2004, the Government of Canada also issued a memorandum to the provinces indicating its interest in harmonizing regulations because of complaints by Canadian farmers that some important pesticides were cheaper in the United States than in Canada.

Interestingly, these federal initiatives have been introduced even though the U.S. EPA and Canada's PMRA, together with Mexico, established a NAFTA Technical Working Group to address the issue of pesticide regulation harmonization in 1998. One focus of the working group's current five year agenda, established in November of 2003, is the development of NAFTA labels for pesticides. However, there is no evidence of any substantive progress on the issue. In addition, apparently, a NAFTA label would only be issued at the request of the manufacturer and therefore would not address North American agricultural producers' concerns about price discrimination.

4. The Price Effects of Agricultural Chemical Market Segmentation: The Evidence

Some evidence of price differences in the Canadian and U.S. agricultural chemical markets has been provided in previous studies. This study focuses on more recent evidence for Alberta and Montana obtained from two simultaneously administered "point in time" surveys of prices for 13 agricultural chemicals from retail agricultural chemical dealerships close to the Canada-U.S. border. A random survey of retail agricultural chemical dealership was administered in Northern Montana and a non-random survey of similar dealerships was administered in Southern Alberta. The

surveys asked respondents on both sides of the border to provide current retail prices for "cash and carry" sales of comparable containers of each agricultural chemical.

In Alberta, the survey was administered by the Pest Risk Management Unit of the Crop Diversification Division of Alberta Agriculture, Food and Rural Development to 14 dealerships whose collective market shares in southern Alberta were estimated to be about 80 percent. In northern Montana, a random survey was administered by the Montana State University Agricultural Marketing Policy Center in collaboration with the Montana Department of Agriculture. In Montana, retailers considered likely to serve both Alberta and Montana agricultural producers were located along or near U.S. Route 2, an east-west highway known as "the Hi-line," that runs parallel to and about 35 miles south of the U.S.-Canadian border. In Alberta, retailers considered likely to serve both Montana and Alberta agricultural producers were located along or near Canada Highway 3, also an east-west highway that in Alberta runs parallel to and about 50 miles north of the U.S. – Canadian border. [9]

[9] Information on dealership locations provided by the Montana Department of Agriculture indicated that 120 Montana agricultural chemical dealerships were potential outlets for agricultural producers in both Montana and Alberta. Seventy of these retailers were randomly selected for potential inclusion in the Montana sample and contacted by telephone to ascertain whether the business was an applicator dealing in a very limited number of chemicals or an agricultural chemical dealer selling many of the chemicals of concern at retail. Applicators were excluded from the survey both because of the limited number of chemicals they handled and because many applicators only sell agricultural chemicals to agricultural producers in combined chemical/application packages. The sample selection process was completed when 40 agricultural chemical dealers willing to respond to the survey had been identified. Each of these 40 randomly selected retailers received survey forms within two working days of being contacted. Thirty-two usable survey forms with usable responses were returned within 14 days by these retailers, an initial response rate of 75 percent. In Alberta, a total of 22 agricultural chemical dealers were identified as potential retail sources of agricultural chemicals for U.S. agricultural producers. All 22 retailers were contacted by Alberta Agriculture, Food and Rural Development and 14 responded to the survey. Alberta Agriculture, Food and Rural Development estimated that jointly these 14 retailers represent 80 percent of the agricultural chemical market in southern Alberta.

The survey, administered to U.S. and Canadian retailers selling agricultural chemicals directly to farmers and ranchers, included 12 herbicides and one pesticide that are widely used both in Alberta and Montana. The agricultural chemicals included in the survey were selected from a list of chemicals identified by the Montana Department of Agriculture in collaboration with representatives of Montana commodity organizations and agribusiness organizations that include agricultural chemical dealers. Alberta Agriculture, Food and Rural Development pesticide experts then identified agricultural chemicals on the Montana list that were also registered and used in Alberta.

Agricultural chemical companies market the same or very similar products under different brand names in Canada and the United States (see table 1). Two of the 13 agricultural chemicals in this study, Mirage and Touchdown, were non-selective herbicides used on fallow and some non-cropland areas. Six - Amine 4 and 2, LV6, Bronate Advanced, Clarity, Achieve SC, and Discover - were herbicides used for broadleaf weed control in wheat, barley and other small grain crops and on fallow and some non-cropland applications. Four – Everest, Puma 1EC, Ally XP, and Express EP – were selective herbicides used primarily to control grassy weeds, including wild oats in wheat and barley and one was a general purpose insecticide, Warrior (with Zeon).

For each chemical, respondents were given descriptions of active ingredients and formulations obtained from each chemical's U.S. or Canadian product labels. They were then asked to (1) provide prices for either two or three sizes of containers (generally 2.5 gallon, 110 gallon, and 220 gallon containers), (2) identify the manufacturer of the chemical, and (3) provide any additional pricing information on quantity or manufacturer program discounts to farmers. Respondents in both Alberta and Montana provided very

little information on quantity or program discounts and, with very few exceptions, respondents from Alberta provided price data only for small containers. Thus, the results presented here are restricted to comparisons of prices for agricultural chemicals sold in small containers (2.5 gallon jugs in the U.S. and 10 liter jugs in Canada).

Every effort was made to compare products with identical active ingredient formulations, but nevertheless some differences in formulations did persist. Data from the labels for each agricultural chemical indicated that the amount of active ingredient per gallon (or ounce) of sales was different for 3 of the 13 chemicals (Amine 4, LV 6, and Bronate Advanced). For these three chemicals, the ratios of the active ingredients in the Canadian products to the active ingredients in the comparable U.S. products were used to adjust the Canadian per unit of sale price (per gallon or per ounce) to an equivalent price for a unit of the product with same amount of active ingredient as in the U.S. product.

These adjusted prices and their associated estimated standard deviations, reported in Table 2, were used to carry out standard student T comparison of means tests for samples of different sizes. The null hypothesis is that the price of a given chemical in Montana is equal to the price of that chemical in Alberta. Results are presented in Table 3. These results show that for all but one of the 13 agricultural chemicals, Mirage or Roundup Original, average prices were statistically significantly different between northern Montana and southern Alberta. Monsanto's Roundup products now face extensive competition from generic glyphosates as patent rights for the product have expired in both Canada and the United States. Most of the other products are produced by a single chemical company and face no competition from generics.

Average prices of five chemicals were significantly higher in southern Alberta than in northern Montana (Table 3). Four - LV 6 (2, 4-D Ester LV 600), Amine 4 (2, 4-D Amine 500), Clarity (Banvel II) and Ally XP (Ally Toss and Go) – are selective herbicides used to control broadleaf weeds in crops such as wheat and barley and on fallowed or CRP land, and on other "non-cropland" areas. The fifth was the general purpose insecticide Warrior with Zeon (Matador 120 EC).

Average prices for the remaining seven agricultural chemicals were statistically significantly higher in northern Montana than in southern Alberta. Touchdown (and Touchdown iQ) is a non-selective herbicide used for weed control on fallow and on non-cropland areas. Bronate Advanced (and Buctril M), and Express XP (and Express Toss and Go) are selective herbicides to control broadleaf weeds in wheat and barley and also for fallow, CRP and non-cropland areas. Achieve SC (and Achieve Liquid), Discover (and Horizon 240 EC), Everest (and Everest), and Puma 1 EC (and Puma 120 Super) are selective herbicides used to control grassy weeds, including wild oats and pigeon grass, in growing crops of wheat and barley.

Although the average prices of a chemical may be statistically significantly different between Montana and Alberta, the economic importance of such differences is what matters. If price differences are small, then Canadian and U.S. farmers may have little to gain from the harmonization of pesticide regulations. The last column of table 3 shows the average price difference for each chemical as a percentage of the U.S. average price for the chemical. In table 3, in three cases, the price differences are relatively small and amount to less than 10 percent of the U.S. price, although in one case, Discover, that represents an absolute difference of $52 per gallon. In eight cases, the price differences

lie in the range of 19 to 31 percent of the U.S. price. Thus, the prices of all but one of the thirteen agricultural chemicals examined in this study exhibit statistically significant differences and, in most cases, the differences appear to be economically important.

One possible explanation for these differences is that agricultural dealers in Canada may face systematically different costs. Possible sources of such differences are differences in product transportation costs, taxes, wages, and other dealership costs. These all seem unlikely as explanations of the above results. First consider transportation costs. Several of these chemicals are purchased in relatively large quantities by individual farmers (for example, Amine 4 is purchased by many Montana farmers in 110 gallon shuttles) and are shipped in bulk to dealers in both Alberta and Montana, in some cases from the same production facility under different labels. Bulk shipping costs by truck from Alberta to Montana for two fertilizers - urea and anhydrous ammonia - were estimated to be about $10 per ton per 100 miles in August 2004 (where a ton is roughly equivalent to about 200 gallons of chemical).[10] Thus shipping costs amounted to approximately five cents per gallon. Doubling or quadrupling this estimate still implies transportation cost differences of only about 20 cents per gallon, which is small compared with the range of average price differences of between $2.89 and $78.78 per gallon among the twelve chemicals with statistically significant price differences.

Agricultural chemical dealer costs may be systematically different in Alberta and Montana. For example, exchange rate adjusted wages could be lower in Alberta than in Montana. Similarly, there may be systematic differences in tax burdens, energy and other costs. However, if these cost differences were what mattered, then we would expect retail prices systematically to be either all higher or all lower in one of the two regions

[10] Grain industry sources provided this estimate.

(Alberta or Montana). This is not the case. Prices are higher in Alberta for five chemicals and higher in Montana for seven chemicals. This suggests that third-order price discrimination is the real issue.

Table 3 shows the companies that manufacture each chemical, as well as cross-border average prices and price differences. The one chemical for which there is no significant difference in prices is Roundup Original. The product, whose active ingredient is glyphosate, is produced and sold by Monsanto, which held a U.S. patent on the product until 2002, but generic glyphosates are now also sold by several other companies in both Canada and the United States. Among the other twelve chemicals, two face generic competition or are produced by several competing companies (LV6 and Amine 4). The remaining ten are produced either by a single manufacturer (four by Syngenta, two by DuPont, one each by BASF and Bayer) or by Bayer in collaboration with either Aventis or Arvesta. These results suggest that generally the economically and statistically significant price differences are associated with market power and differences in elasticities of demand.

Assuming that this is the case, a natural question is why demand is more own-price elastic in Canada for some chemicals and less own-price elastic for others. Two possibilities spring to mind. The first is that differences in crop mixes in Canada and the United States lead to differences in demand elasticities. While this is a possibility, given that (1) arbitrage is feasible within Canada across large regional markets and also within the United States and (2) complex mixes of crops are raised in both countries, it seems unlikely that crop mix is the main issue.[11]

[11] It should be noted that the ability to arbitrage across states in the United States may be restricted because each state must registered a chemical for use. However, if a herbicide is approved for a specific use by

Differences in regulatory regimes may also be important. Suppose, for example, that chemical A is approved for use in Canada but so too are other chemicals that may have different formulations (including different active ingredients) that perform similar functions. In addition, chemical A is also registered in the United States, but no close substitutes are also approved. The difference in the regulatory regimes may well account for the difference in the elasticities of demand (higher in Canada and lower in the United States), and the higher price for chemical A in the United States. The situation may be the exact opposite for chemical B. While, currently, no exhaustive evidence is available to determine which hypothesis is correct, the case of Roundup suggests that differences in regulatory regimes are important. Once Monsanto's U.S. patent for its Roundup product had expired in 2002, as it already had in Canada where close substitutes were then registered for use, similarly close substitutes were registered for use in the United States and differences in prices in the two markets essentially disappeared.

The question then arises as to why there are differences in the regulatory regimes. In some cases, serendipity may be at work: some firms simply have not sought registration in, say, Canada but have obtained registration in the United States (perhaps because of differences in the sizes of the markets and regulatory approval costs). In others, lobbying of the regulatory authority by producers may be relevant. However, as in the case of Roundup, differences in patents and the timing of patent expirations also may be important.

EPA and registered for that use in one state, then typically other states will also register the herbicide for that use (say control of wild oats in wheat fields). Moreover, either users (farmers) or manufacturers may initiate the state level registration process.

5. Implications of Harmonization and Conlcusion

A casual interpretation of the findings reported in table 3 suggests that harmonization may not yield large gains for U.S. farmers. While eight chemicals are more expensive in the U.S., four are more expensive in Canada. Thus harmonization may increase prices for some U.S. chemicals and reduce them for others. If the U.S. has a relatively large share of the aggregate Canadian-U.S. market then the resulting price reductions for the chemicals for which the U.S. is initially the high price market may be relatively small, while price increases for the chemicals in which the U.S. is initially the low price market may also be small. However, casual appearances can be deceptive.

Suppose, for any given chemical that is priced low in the Canadian market, the absolute value of the own price elasticity of demand is large or almost infinite. This would be the case where there are several close or reasonable substitutes available in that market, but, either because of differences in regulatory decisions or because of differences in patent rights, not in the U.S. market. In that case, harmonization would essentially provide a back door for indirect competition from the substitute chemicals available in Canada but not the U.S. In such a case, as long as the chemical of interest remained available the Canadian market (and therefore importable to the United States under the harmonization initiative), the U.S. price would fall to the Canadian price and the gains to U.S. farmers would be substantial.

Data on demand elasticities in the two markets are not currently available. Thus it is not feasible to obtain quantitative estimates of the welfare effects of harmonization. However, it does seem clear that agricultural chemical companies do exploit the market segmentation created by differences in the Canadian and U.S. regulatory processes for

their products. This suggests that they have much to lose from harmonization initiatives. In contrast, if own price demand elasticities are relatively large in the markets that are low priced under market segregation then almost surely U.S. farmers have much to gain from harmonization.

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Table 1. Agricultural Chemicals and Their Major Target Species and Major Uses

Agricultural Chemicals [A]	Target Species/Major Uses
Mirage and *Roundup Original*	non-selective herbicide for general weed control; fallow and non-cropland areas
Touchdown and *Touchdown iQ*	non-selective herbicide for general weed control; fallow and non-cropland areas
Amine 4 and *2, 4-D Amine 500*	selective herbicide for control of broadleaf weeds; certain crops and non-cropland areas
LV 6 and *2,4-D Ester LV 600*	selective herbicide for broadleaf weed control; wheat, barley and non-cropland areas
Bronate Advanced and *Buctril M*	selective herbicide for certain broadleaf weeds; wheat, barley, oats; rye and flax
Clarity and *Banvel II*	selective herbicide for broadleaf weeds; CRP, fallow, small grains, and farmstead
Achieve SC and *Achieve Liquid*	selective herbicide for grassy weeds; wheat and barley
Discover and *Horizon 240EC*	selective herbicide for grassy weeds; wheat
Everest and *Everest*	selective herbicide for wild oats, green foxtail and other grassy weeds and broadleaf weeds; spring, durum , and winter wheat
Puma 1EC and *Puma 120 Super*	selective herbicide for pigeongrass, wild oats and millet and barnyardgrass; wheat and barley
Ally XP and *Ally Toss and Go*	selective herbicide for broadleaf weeds; wheat, barley and fallow
Express EP and *Express Toss and Go*	selective herbicide for broadleaf weeds; wheat, barley and fallow
Warrior (with Zeon) and *Matador 120 EC*	general insecticide

[A] The first brand name is the chemical's name in the United States and the second is the chemical's name in Canada.

Table 2. Estimated Average Prices and Standard Deviations: Prices Adjusted for Differences in Chemical Formulations (U.S. Dollars)

		Northern Montana			Southern Alberta		
	Units	Average price	Standard Deviation	Number of Obs.	Average price	Standard Deviation	Number of Obs.
Mirage and Round Up Original	gallon	20.94	3.92	15	21.68	0.69	12
Touchdown and Touchdown IQ	gallon	31.28	5.06	5	23.22	0.57	14
Amine 4 and 24D Amine 500[A]	gallon	12.16	0.46	28	15.56	0.17	5
LV6 and 24D Ester LV 600[A]	gallon	19.36	0.76	29	19.53	2.04	5
Bronate Advanced and Buctril M	gallon	59.43	3.28	26	42.07	1.36	14
Clarity and Banvel 2[A]	gallon	93.47	3.63	29	96.85	1.89	14
Achieve SC and Achieve Liquid	gallon	220.85	11.1	29	208.37	3.48	12
Discover and Horizon 240 EC	gallon	496.37	23.7	31	448.31	5.54	14
Everest and Everest	ounce	23.45	1.25	29	17.50	0.61	14
Puma 1EC and Puma 120 Super	gallon	181.33	7.57	30	128.97	6.21	14
Ally XP and Ally Toss and Go	ounce	23.27	1.14	23	37.37	1.01	13
Express XP and Express Toss and Go	ounce	18.63	1.14	29	14.82	0.23	7
Warrior and Matador 120 EC	gallon	282.76	8.41	21	361.54	13.15	14

[A] These four chemicals had different formulations in Canada and the United States.

Table 3: Montana and Alberta Agricultural Chemical: Prices and Price Differences Adjusted for Differences in Formulations)

Chemical	Firms	Units	U.S. Price (US $)	Canadian Price (US $)	Price Difference (U.S. Price – Canada Price) (US $)	T-test Value	Percentage Price Difference[A]
Mirage and Roundup Original	Generic/ Monsanto	gallon	20.94	21.68	-0.74	-0.65	-3.5%
LV 6 and 2, 4-D Ester LV 600	Several	gallon	19.36	23.22	-3.86[B]	-7.15	-19.9%
Amine 4 and 2,4-D Amine 500	Several/ Generic	gallon	12.16	15.05	- 2.89[B]	-13.71	-23.8%
Clarity and Banvel II	BASF	gallon	93.47	96.85	- 3.38[B]	- 3.26	-3.6%
Ally XP and Ally Toss and Go	DuPont	ounce	23.27	37.37	-14.10[B]	-37.09	-60.6%
Warrior (Zeon) and Matador 120 EC	Syngenta	gallon	282.76	361.54	-78.78[B]	-21.68	-27.9%
Touchdown and Touchdown Iq	Syngenta	gallon	31.28	23.22	8.06[B]	6.17	25.8%
Bronate Advanced and Buctril M	Bayer	gallon	59.43	44.94	14.49[B]	15.56	24.4%
Achieve SC and Achieve Liquid	Syngenta	gallon	220.85	208.37	12.48[B]	3.79	5.7%
Discover and Horizon 240 EC	Syngenta	gallon	496.37	448.31	48.06[B]	7.45	9.7%
Everest and Everest	Arvesta/Bayer	ounce	23.45	17.50	5.95[B]	16.80	25.4%
Puma 1EC and Puma 120 Super	Bayer/Aventis	gallon	181.33	128.97	52.36[B]	22.54	28.9%
Express XP and Express Toss and Go	DuPont	ounce	18.63	14.82	3.81[B]	8.70	20.5%

A. The percentage price difference is computed as the ratio of the difference between the U.S. and the Canadian price to the U.S. price. A negative sign implies that the U.S. price is lower and a positive sign implies that the U.S. price is higher.

B. The symbol B denotes that the difference is statistically significant at the 99% confidence level.