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Welfare Impacts of a Trade Restriction

An Equilibrium Approach and Application in the Potash Industry

Patrick Canning
Harry Vroomen

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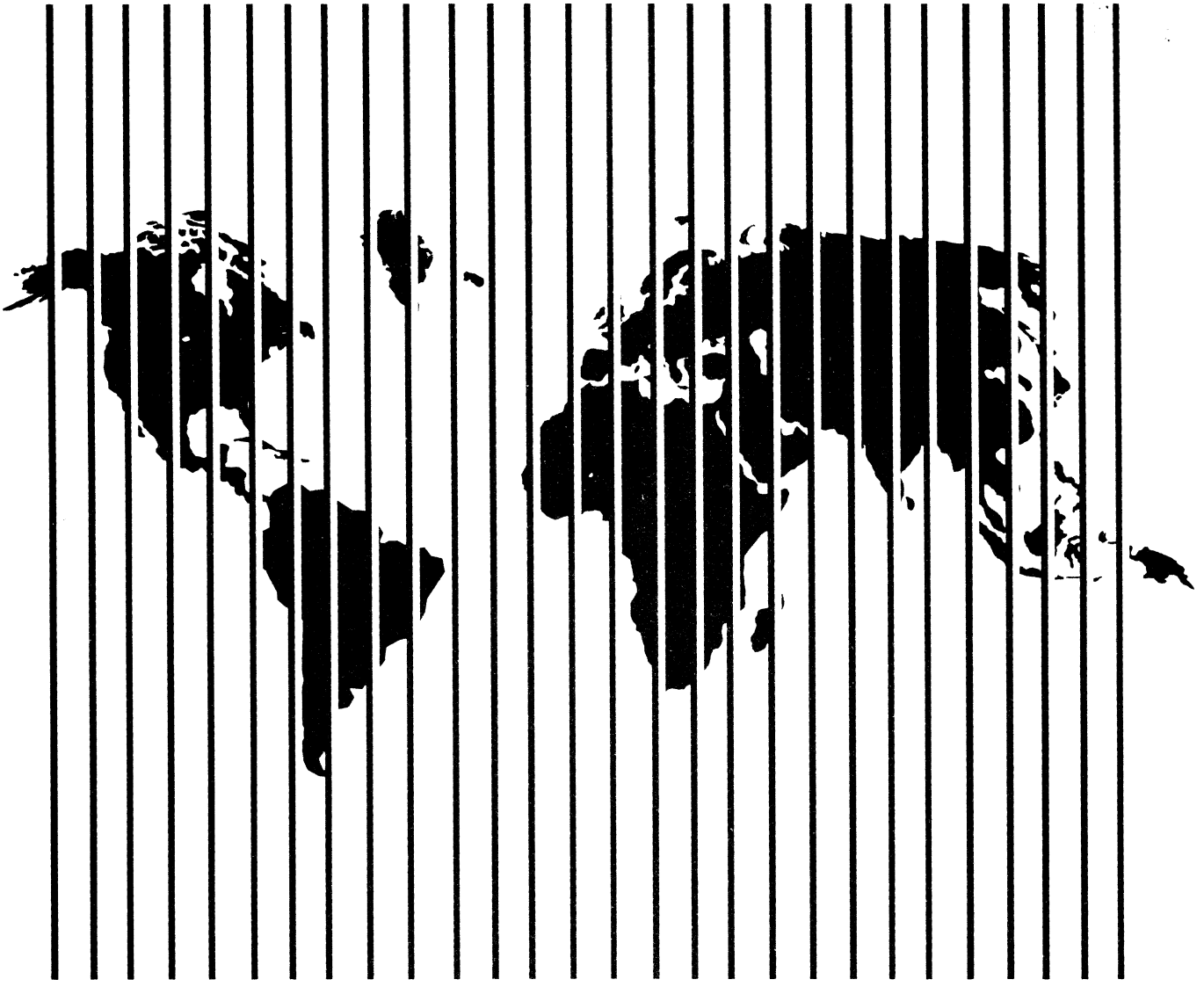

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Welfare Impacts of a Trade Restriction: An Equilibrium Approach and Application in the Potash Industry. By Patrick Canning and Harry Vroomen. Resources and Technology Division, Economic Research Service, U.S. Department of Agriculture. Technical Bulletin No. 1834.

Abstract

A three-sector equilibrium open economy model is developed for measuring welfare effects of a trade restriction. The approach is applied to the U.S./Canadian trade agreement on potash (USCTAP). The net effect of USCTAP to U.S. firms, households, and the government over the July 1987-June 1992 period was a social welfare cost of $815 million. The big losers were U.S. potash users (-$956 million), while Canadian potash producers (+$723 million), U.S. potash producers (+$211 million), and other foreign producers (+$99 million) were the big winners (in 1987 dollars). Other countries that import U.S. goods that contain potash as an input incurred additional costs of $40 million, due to higher prices of those goods, resulting in a net gain of $59 million to other countries. U.S. taxpayers bear a lighter burden (-$55 million) due to USCTAP.

Keywords: Antidumping, trade, potash, welfare, multivariate transfer function, open economy, government revenue

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Summary

Estimates of welfare impacts from the U.S./Canadian trade agreement on potash (USCTAP) are based on an application of the Harberger model that incorporates two important features. The assumption of a free-market economy prior to intervention is replaced with a model reflecting the primary features of status quo U.S. farm policy. In addition, the economy is open, such that equilibrium is determined in world markets, while inputs and outputs flow between the United States and its trading partners.

The primary impacts of the trade case are obtained by conducting a counterfactual analysis, comparing what actually happened with potash prices and quantities as a result of the trade case to estimates of prices and quantities in its absence. This is accomplished using a multivariate transfer function. Impacts in the primary potash using markets (corn, soybeans, and wheat) are measured using supply/demand equilibrium model simulation.

The impacts are distributed as follows. From 1987/88 through 1991/92, USCTAP produced gains to industries bringing potash to the U.S. market of $1.03 billion (in 1987 dollars). Of this total, $723 million went to Canadian producers, $211 million went to U.S. producers, and $99 million went to "other" foreign producers. U.S. potash users bore the cost of these gains, plus an additional cost (the Harberger triangle), totaling $1.08 billion. However, $126 million of this cost was passed on to their customers, including $40 million passed on to U.S. trading partners. Deficiency payment outlays are $55 million lower under USCTAP, but only $22 million of this represents a net social savings. The remainder is financed through higher prices for program crops. The net effect of USCTAP to U.S. firms, households, and the government over the 1987/88 through 1991/92 period is a loss of $815 million in social welfare.

Our results reveal the importance of considering a model of sufficient generality in order to present meaningful welfare analysis. Estimates show that (1) a large share of both gains and losses resulting from USCTAP are passed on to U.S. trading partners, (2) more than 14 percent of the higher costs born by potash users are passed on to their customers, and (3) considerable government cost savings result from reductions in government outlays for U.S. farm commodity programs.

Although the application is stylized to the USCTAP, the methods and model assumptions presented can be applied to a wide range of trade analyses. Social welfare effects, as well as distributional effects of trade agreements, restrictions on trade, and unilateral liberalization of trade, can be measured using variations of the analysis we have presented.

Welfare Impacts of a Trade Restriction

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Introduction

In February 1987, two New Mexico-based potash companies sought Federal protection from Canadian potash suppliers, alleging that imports from Canada were being dumped on the U.S. market (U.S. Department of Commerce, 1987).[1] In their preliminary determination, the U.S. Department of Commerce (USDC) ruled in favor of the New Mexico producers and issued the following schedule of dumping margins (duties) on Canadian producers of potash:

Company	Margin
Potash Corporation of Saskatchewan	51.90%
International Minerals & Chemical Corporation	9.14%
PPG/Kalium	26.67%
Central Canada Potash	85.20%
Potash Company of America	77.44%
All others	36.63%

Under this ruling, Canadian producers were ordered to make cash deposits or post bonds equal to the dumping margins set for each supplier on all new sales or deliveries of potash into the United States after August 21, 1987.

Following USDC's preliminary ruling, the government of Saskatchewan introduced legislation empowering it to regulate all potash production in the Province. However, even before the legislation was passed, the Potash Corporation of Saskatchewan, Canada's largest potash producer, exerted its market power by raising the price of its exports to the United States. Price hikes by other Canadian companies soon followed. In January 1988, the antidumping case was suspended when eight Canadian potash producers and USDC signed an agreement restricting Canadian producers from dumping potash in the United States at more than 15 percent of the preliminary margins set for each producer. Canadian suppliers agreed, in effect, to honor a price floor established by the USDC.

[1]Names in parentheses refer to sources listed in the References at the end of this report.

Antidumping suits have been a prominent instrument for U.S. producers facing tough foreign competition for their home markets. The potash trade restriction scenario is indicative of the role government plays in commerce between trading partners. That role includes the balancing of protection for both private and social welfare interests as well as relations with trading partners.

A paradigm for general equilibrium analysis of international trade has been developed and advanced over a long period of time in the applied welfare economics literature. However, there have been surprisingly few applications of this model in the trade literature, in large part due to the data demands of such an analysis. A goal of this paper is to present an empirical example consistent with the model, with tractable applications in trade analysis.

The U.S./Canadian trade agreement on potash, originally set to expire in January 1993, was extended by the USDC in March. This report provides an impact analysis of the initial agreement and examines the distributional welfare impacts on U.S. producers and consumers of agricultural products. The methods presented in this trade case are applicable to the analysis of most forms of restrictions on trade. Our analysis of the potash case will carry out the application of a general equilibrium welfare analysis in the context of international trade.

Policy issues were outlined in the introduction. The remainder of the report is organized as follows. With the aid of supply/demand figures, we establish that our goal of determining the welfare impacts of the U.S./Canadian trade agreement on potash (USCTAP) requires a general equilibrium approach. Such an approach captures the full path of economywide price/quantity adjustments.

We then present a three-sector open economy model for the purpose of identifying economywide impacts of the USCTAP. The implications from introducing USCTAP reveal several rules for approaching the empirical problem. First, the change in the area below an equilibrium demand curve and above market price, when a distortionary policy is introduced in an otherwise (un)distorted economy, represents the economywide welfare impacts of the distortion. Next, when secondary markets are impacted by the new market distortion, then it may also be necessary to measure welfare impacts in these markets. Finally, the sum of all welfare impacts measured in this model represents economywide impacts plus the welfare impacts to foreign consumers and producers of the affected U.S. commodity markets.

Next, we outline the empirical problem. We use a multivariate transfer function to simulate where prices and quantities would have stood in the absence of USCTAP to estimate the equilibrium demand curve. This permits us to empirically measure the primary impacts of the trade case. Impacts in the primary markets that use potash as an input (corn, wheat, and soybeans) are measured from supply/demand equilibrium model simulation.

Last, we apply the empirical model for deriving a compensated demand curve and calculate the secondary effects. The results are reported and implications discussed. Results indicate that the impacts of the USCTAP were significant. U.S. farmers, suppliers to the farm sector, and consumers of U.S. farm products experienced a considerable decline in welfare; meanwhile, Canadian potash producers benefited considerably, as did U.S. producers. U.S. government outlays for commodity programs were also reduced.

The Economic Problem

When a free-market equilibrium is distorted, the net effects are captured in the newly distorted market. In a closed economy, this net effect represents the economywide welfare impacts of the market

intervention. Considerable significance is placed on this result, which has formed the basis for empirical studies of welfare impacts in areas too numerous to mention. The implication of this approach, which is developed in Harberger (1971), is that empirical policy analysis need not go beyond the market targeted for intervention to capture the economywide rippling effects of the intervention.

There are several limitations to this approach. First, the assumption of a free-market economy is unrealistic when distortions already exist in markets that are either directly or indirectly affected by a new intervention. Welfare implications may result that are not reflected in the newly distorted market. In such cases, these otherwise distorted markets can be identified and considered separately. In most instances, it is simply a matter of calculating changes in government revenues in those markets. Second, the relevant empirical approach to welfare analysis is through general equilibrium modeling. This is particularly important when considering the newly distorted market, where impacts are most pronounced and carry economywide welfare significance. A third limitation for empirical work is the assumption of a closed economy. Clearly, a closed economy model has few applications in empirical general equilibrium research. Although few, if any, empirical applications of the Harberger model explicitly assume a closed economy, many studies interpret the change in area between equilibrium supply and demand curves as the equivalent of economywide welfare impacts. Any commodity market affected by a new intervention and traded in an international market also has welfare implications for these outside economies. Further, these effects are captured by the "Harberger estimates"[2] (see Bullock (1993) for a discussion of this topic). Consequently, the Harberger estimates, and the secondary market estimates, are not necessarily attributed solely to domestic interests. In some instances, it may be sufficient to acknowledge this result, while in other cases, some form of adjustments to the estimates may be attainable. Certainly, in the case of U.S. demand for Canadian potash, U.S. agricultural commodities that use potash as a production input are traded on international markets.

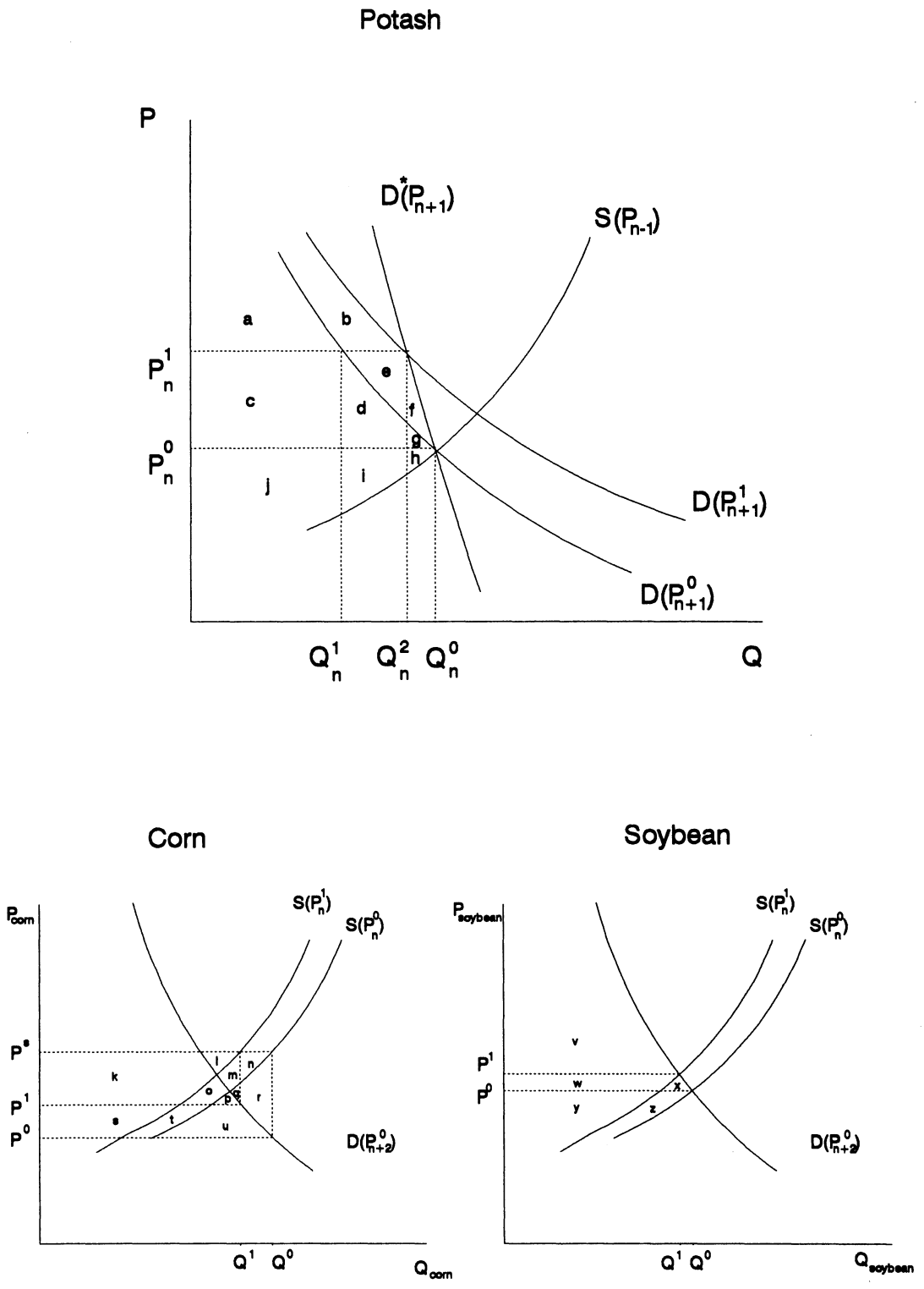
Figure 1 presents the intuition. We have a hypothetical market depiction of the U.S. potash, soybean, and corn markets. In the potash market, the intersection of $D(P^0_{n+1})$ and $S(P_{n-1})$ at P^0_n, Q^0_n is the market clearing level of potash in the United States.[3] In the U.S. corn market, the initial intersection of supply and demand is determined by the curves $S(P^0_n)$ and $D(P^0_{n+2})$. However, a government target price is in place in the corn market (we assume 100-percent program participation). This target price program drives a wedge between the average price suppliers receive (P^s_{n+1}) and the average price consumers pay (P^d_{n+1}). Corn production is initially at Q^0_{n+1}, and government deficiency payments equal the total area k through u (fig. 1). The soybean market is in equilibrium at price P^0 and quantity Q^0, since the government loan rate is nonbinding. USCTAP effectively establishes a price floor on Canadian imports of potash into the United States. As a consequence, the average market price of potash becomes P^1_n. The instantaneous response to this sudden increase in price is a movement along the $D(P^0_{n+1})$ demand curve back to the point P^1_n, Q^1_n.

At this point, a partial equilibrium analysis would be complete. The net result is a shift from consumers to producers of area c, and a deadweight loss of area d+g+h+i. But a partial equilibrium analysis fails to account for compensations in other related markets. For example, the increase in potash prices (P^1_n - P^0_n) will cause U.S. soybean and corn producers to shift production back (due to the increase in the input price), as depicted by the supply curves $S(P^1_n)$. These markets eventually

[2]For exposition, references to the changes in area between general equilibrium supply and demand curves in a newly distorted market will be referred to as "Harberger estimates."

[3]This depiction assumes a vertical market structure (Just and Hueth, 1979), whereby markets n-i are factors of production in market n, and markets n+i are products that use market n output. Equilibrium market outcomes are the same whether a single integrated firm or many small firms characterize the industry.

Figure 1
Potash market price floor with wheat market target price



stabilize at new market prices P^1. The higher soybean price subsequently stimulates soybean production up along the new supply curve, and demand for potash shifts outward to $D(P^1_{n+1})$. Note that the producer price for corn remains the target price, and production is scaled back to reflect the higher cost of production. Even at the new demand level, the price floor is still binding, so there is no further compensation in this simple example. After all adjustment is completed, the new market clearing price/quantity level in the potash market is P^1_n, Q^2_n. If this exercise were carried out at various price floor levels in the potash market, the locus of P,Q intercepts would trace out an equilibrium demand curve (D^*) which would run through P^0_n, Q^0_n and P^1_n, Q^2_n.

To appreciate the significance of D^*, first consider the case of a perfectly elastic demand for soybean products (market n+2) and a perfectly elastic supply of mined potash (market n-1). The former assumption is not realistic, but we later show this assumption is unnecessary. Presently, it simplifies the figure and shows how equilibrium adjustments can be measured in an intermediate market. Also assume that all other vertically and horizontally related markets, including the corn market, are not affected by the distortion in market n. In this case, the producer welfare impact in market n+2 is equivalent to the change in consumer surplus in market n+1 [-(w+x)]. Producers in market n+1 lose the difference from the areas between price received and equilibrium supply at the initial and subsequent market outcomes (w - z). So the net effect to producers and consumers is -(x+z). But this area is precisely the same as the area between P^0_n and P^1_n along the equilibrium demand curve in market n (-c-d-e-f-g). Because we assume a perfectly elastic supply of potash (market n-1), the only remaining impact is market n producer surplus (c+d+e-h). So the net effect of the price floor intervention is measured between the compensated supply and demand curves in the potash market (-f-g-h). This result implies that equilibrium net private welfare impacts are fully captured by the "Harberger estimates" in the newly distorted market.[4]

If we include the corn market in the analysis, first note that the target price (P^s) is still binding, and does not change, while the market clearing price and quantity must adjust from P^o and Q^o to P^1 and Q^1, so this market requires special attention. From figure 1, corn producer surplus declines by area (n+m+o+t). As in the case of the soybean market, the corn producer surplus effects are measured beneath the potash equilibrium demand curve. The surplus effects for corn products (market n+2) is not reflected in the potash market, because the change in the market price for corn (P^1-P^o) has no effect on the price received by corn producers, so this surplus effect, -(s+t+u), must also be counted. Finally, the new equilibrium is attained with a government expenditure savings of area s+t+u+n+r. Adding up the equilibrium net welfare effects, the total cost of the price floor in the corn, soybean, potash, and related markets, including government revenue effects, is represented by area -(f+g+h)+n+r.

To generalize the results presented in this illustration to a full equilibrium analysis, further figures would become increasingly complicated, and the intuition would be lost. In the next section, a mathematical derivation of the results shown in figure 1 is presented for a more generalized market setting that reflects status quo market equilibrium. We will show that the results of this section hold when several related markets are affected by the price floor, and some of these markets also have existing distortions. Of special note, we formalize the empirical approach to consideration of target price program impacts, and present the empirical consequences of an open economy model.

[4]This is actually only true for a closed economy. This qualification will be discussed in further detail in the next section.

The Model

The economy is comprised of households, firms, government, and net exports. There are N goods produced, such that each good q_n uses a subset of the remaining N-1 goods as inputs. Goods may be used both for final consumption and as factors of production. The optimizing firm faces fixed levels of some capital inputs. There are J households. Each derives utility from consuming the N goods, and seeks to maximize utility by consuming an optimal mix of goods.

First order conditions of producer n's restricted profit function, and household j's expenditure function provide expressions for both goods supplied by firms and demanded by households;

$$\hat{q}_{n,k}(P_1^*,\ldots,P_N^*), \tag{1}$$

$$\tilde{q}_{n,j}(P_1^*,\ldots,P_N^*,\bar{U}_j), \tag{2}$$

where ~ denotes a firm's supply curve (derived input demand if negative), ^ denotes a household's demand curve (resource supply is negative), and $\bar{U}$ is the lower bound of household utility attainment.

Let η represent a 1 X L vector of existing market distortions economywide; $\eta = (\eta_1, \ldots, \eta_L)$. Implicitly, all prices can be expressed as functions of η, such that $P = P(\eta)$. We define $\eta^a = (\eta_1^1, \ldots, \eta_{L-1}^1, \eta_L^0)$, and $\eta^b = (\eta_1^1, \ldots, \eta_L^1)$. A "0" superscript implies a nonbinding restriction, such that the free-market outcome prevails. η_L represents the regulation being introduced. η^a is associated with the status quo, while η^b introduces a new regulation to the status quo. Markets re-equilibrate to the new regulation through a "reshuffling of available resources" (Harberger, 1971, p. 793).

To determine the equilibrium welfare effects of a countervailing duty (tariff), a trade quota, or a price floor, importing producers and domestic consumers of the regulated good face both technical and legal constraints. Let Q_k represent the 1 X N vector of all products produced or purchased by producer k. The netput vector $f_k(Q_k)$ defines the production technology. Producers are constrained to the set of all Q's such that $f_k(Q_k) = 0$ is satisfied. Also, with a legal price floor or tariff in place, producers are constrained to export to the United States no more than the quantity demanded at the established price floor or tariff, or no more than the established quota. That is, for an enforced price floor (such that no black markets develop), suppliers have no incentive to produce more than $\bar{q}_m$, which is equal to the input demand for the regulated good at the price floor or tariff level, and is less than producers would be willing to supply at this price (see Gardner, 1987, pp. 36-37). Restricted profit maximization is then defined as:

$$\underset{\hat{q}_n^s,\ \hat{q}_n^d}{Max}\ R_k = \sum_{n=1}^{N} P_n(\eta)(\hat{q}_{nk}^s + \hat{q}_{nk}^d), \text{ subject to } f_k(Q_k) = 0, \textit{ and } \hat{q}_{mk}^s \le \bar{q}_m, \tag{3}$$

where R_k is the restricted profits of producer k, and $P_n(\eta)$ is the market price of good n ($n \in [1\ N]$). The necessary conditions for a unique maximum value (with binding restrictions) are:

$$\frac{\partial \mathcal{L}}{\partial \hat{q}^{s}_{nk\ (n\neq m)}} = \frac{\partial \mathcal{L}}{\partial \hat{q}^{d}_{nk\ (n\neq m)}} = P^{*}_{nk} - \lambda_R \frac{\partial f_k}{\partial \hat{q}_{nk}} = 0,$$

$$\frac{\partial \mathcal{L}}{\partial \hat{q}^{d}_{mk}} = P^{*}_{mk} - \lambda_R \frac{\partial f_k}{\partial \hat{q}_{mk}} = 0, \tag{4}$$

$$\frac{\partial \mathcal{L}}{\partial \hat{q}^{s}_{mk}} = P^{*}_{mk} - \lambda_R \frac{\partial f_k}{\partial \hat{q}_{mk}} - \mu_{mk} = 0,$$

where L is the lagrangian function and sufficient conditions for a maximum are met.

The third condition indicates that importers of the regulated good will equate the shadow cost of production with the market price less μ_{mk}. These producers are forced to produce output as if the government has created a price wedge equal to μ_{mk} between the market price and the price received. The wedge is determined by the level of $\bar{q}_m$, which is determined by the tariff, price floor, or quota. Domestic household resource suppliers of the regulated good (for example, $\tilde{q}_m<0$) face the same restrictions and replacing "k" with "j" and "^" with "~" gives the related necessary conditions.

To sort out the economywide effects of the new regulation, we define x_n as the aggregate domestic excess supply of any good n and z_n as the aggregate international excess supply of any good n traded in the domestic market:[5]

$$x_n(P_1(\eta), \ldots, P_{m-1}(\eta), P^{s}_{m}(\eta), P^{d}_{m}(\eta), P_{m+1}(\eta), \ldots, P_N(\eta)) =$$

$$\left[\sum_{k\in K^{sx}_m} \hat{q}_k(P^{s}(\eta)) - \sum_{j\in J^{sx}_m} \tilde{q}_j(P^{s}(\eta))\right] + \left[\sum_{k\in K^{dx}_m} \hat{q}_k(P^{d}(\eta)) - \sum_{j\in J^{dx}_m} \tilde{q}_j(P^{d}(\eta))\right], \tag{5}$$

$$z_n(P_1(\eta), \ldots, P_{m-1}(\eta), P^{s}_{m}(\eta), P^{d}_{m}(\eta), P_{m+1}(\eta), \ldots, P_N(\eta)) =$$

$$\left[\sum_{k\in K^{sz}_m} \hat{q}_k(P^{s}(\eta)) - \sum_{j\in J^{sz}_m} \tilde{q}_j(P^{s}(\eta))\right] + \left[\sum_{k\in K^{dz}_m} \hat{q}_k(P^{d}(\eta)) - \sum_{j\in J^{dz}_m} \tilde{q}_j(P^{d}(\eta))\right]. \tag{6}$$

K_m^{sx} (J_m^{sx}) is the set of all domestic firms (resource suppliers) that supply good m, and K_m^{dx} (J_m^{dx}) is the set of all other domestic firms (consumers), including those that demand good m. K_m^{sz}, J_m^{sz}, K_m^{dz}, and J_m^{dz} are defined identically, but for international firms and consumers. To economize on notation, m can represent a single market, or a group of markets that have different buyer and seller prices. We denote the term within the first set of squared brackets in equations 6 and 7 x_n^{sm} and z_n^{sm}, respectively, and note that this is the aggregate excess supply of good n by firms and resource suppliers that supply m. The term within the second set of square brackets in these equations is denoted x_n^{dm} and z_n^{dm}, and

[5]The following proof builds on notation and methods presented in Bullock (1993).

represents the aggregate excess demand of good n by firms and consumers who are net demanders of good m, or nonparticipants in market m.

Let X^{sm} (X^{dm}) equal the difference between aggregate quasi-rents of domestic suppliers (consumers/nonparticipants) in market(s) m, and the aggregate expenditures of consumers/resource suppliers that are suppliers (consumers/nonparticipants) in market(s) m. Parallel arguments define Z^{sm} and Z^{dm} for international suppliers and consumers/nonparticipants. Let M_j denote household j's expenditure function, X^{lm} (Z^{lm}) a 1-by-N vector of excess domestic (international) supply levels in each market, and $P^l(\eta)$ a 1-by-N price vector ($l \varepsilon [s\ d]$). X^{sm} and Z^{sm} summarize the economic activities of all agents who face the $P^s(\eta)$ price vector, while X^{dm} and Z^{dm} summarize the economic activities of all agents who face the $P^d(\eta)$ price vector:

$$X^{sm}(P^s(\eta)) = \sum_{k\in K_m^{sx}} R_k^{sm}(P^s(\eta)) - \sum_{j\in J_M^{sx}} M_j^{sm}(P^s(\eta)) \equiv P^s(\eta)\cdot x^{sm}(P^s(\eta)),$$

$$X^{dm}(P^d(\eta)) = \sum_{k\in K_m^{dx}} R_k^{dm}(P^d(\eta)) - \sum_{j\in J_M^{dx}} M_j^{dm}(P^d(\eta)) \equiv P^d(\eta)\cdot x^{dm}(P^d(\eta)),$$

$$Z^{sm}(P^s(\eta)) = \sum_{k\in K_m^{sz}} R_k^{sm}(P^s(\eta)) - \sum_{j\in J_M^{sz}} M_j^{sm}(P^s(\eta)) \equiv P^s(\eta)\cdot z^{sm}(P^s(\eta)), \tag{7}$$

$$Z^{dm}(P^d(\eta)) = \sum_{k\in K_m^{dz}} R_k^{dm}(P^d(\eta)) - \sum_{j\in J_M^{dz}} M_j^{dm}(P^d(\eta)) \equiv P^d(\eta)\cdot z^{dm}(P^d(\eta)).$$

If we totally differentiate the system in (7) and evaluate the resulting expressions along their paths of integration from $P^l(\eta^a)$ to $P^l(\eta^b)$, we have the measure of changes in X^{sm}, X^{dm}, Z^{sm}, and Z^{dm} from the introduction of regulation η^b to the status quo. This expression can be represented by line integrals (Purcell, 1978, p. 593):

$$\Delta X^{sm} = \sum_{n=1}^{N} \int_{L^s} X_n^{sm}(P^s)dP_n^s, \qquad \Delta X^{dm} = \sum_{n=1}^{N} \int_{L^d} X_n^{dm}(P^d)dP_n^d,$$

$$\Delta Z^{sm} = \sum_{n=1}^{N} \int_{L^s} Z_n^{sm}(P^s)dP_n^s, \qquad \Delta Z^{dm} = \sum_{n=1}^{N} \int_{L^d} Z_n^{dm}(P^d)dP_n^d. \tag{8}$$

Note that $P_n^s = P_n^d$ for all n except n=m. Adding together the 4 expressions in 8:

$$\Delta X^{sm} + \Delta X^{dm} + \Delta Z^{sm} + \Delta Z^{dm} =$$

$$\sum_{n \neq m}\left[\int_{L^s}(X_n^{sm}(P^s)+Z_n^{sm}(P^s))dP_n + \int_{L^d}(X_n^{dm}(P^d)+Z_n^{dm}(P^d))dP_n\right] \tag{9}$$

$$+ \sum_{m}\left[\int_{L^s}(X_m^{sm}(P^s)+Z_m^{sm}(P^s))dp_m^s + \int_{L^d}(X_m^{dm}(P^d)+Z_m^{dm}(P^d))dp_m^d\right].$$

Equation (9) separates market(s) m from the rest of the economy, since it is the only regulated market(s). The summation over the term within the first set of outer brackets is the product of changes in excess supply and market price for all goods $n \neq m$ evaluated along $P^s(\eta) = P^d(\eta)$ for $\eta \in [\eta^a\ \eta^b]$. However, at all points along this path of integration these markets clear,[6] and this implies that the first line integral within the first set of outer brackets is equivalent to the negative of the second line integral within the same brackets, and the two expressions cancel. The net of changes in quasi-rents and household expenditures, determined along equilibrium supply and demand curves in all unregulated (and regulated but unaffected) markets, due to the new regulation η_L, sum to zero when using Harberger's criteria.

The term within the second set of outer brackets is the summation of market specific impacts in all regulated markets, including the newly distorted market. Recall from our discussion above that producers in regulated market(s) facing a new price floor or import quota will proceed as if the government has driven a wedge between producer price and market price, and will adjust output accordingly. The consequence of the price wedge is a diverging path of integration between the two expressions within the second set of outer brackets.

To complete our account of the impacts of regulation η_L, we note that there is still a government effect, which we denote as ΔT_m. For a tariff, price floor, or import quota (which we define as m1, where m1 always represents a new regulation, and m1+i, $i \in [1\ L\text{-}1]$, are pre-existing regulations), ΔT_{m1} is the product of the effective quantity constraint $\overline{q}_m$, and the resulting price wedge μ_{mk};

$$\Delta T_{m1} = \bar{q}_{mk}(P_m^d(\eta^a) - P_m^s(\eta^b)) = \bar{q}_{mk} \times \mu_{mk}. \tag{10}$$

For all markets m1+i that are affected by regulation η_L and already have a binding regulation, additional impacts on net social welfare result. We present a treatment of two major U.S. policy instruments affecting the agricultural sector: the target-price/deficiency-payment commodity program and the percentage sales tax.[7] Markets with a target price program have a supply/demand system that is defined by a causal relationship from target price ($\bar{P}$) to output supply to market clearing price. The difference between market clearing price at $q^s_{m+i}(\bar{P})$ and the target price is the deficiency payment paid by the government for each unit of output sold. Because of the guaranteed deficiency payment to producers, the market will operate such that $dP^s_{m+i}/d\eta=0$, while $dP^d_{m+i}/d\eta \neq 0$. For our solution to (9) we calculate:

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[6]We can also consider all regulated markets that show no impacts from the new regulation, η_L, to be in this expression. These markets necessarily add zero to the solution of the line integrals.

[7]In appendix D.2 in Just, Hueth, and Schmitz (1982), a number of policy instruments are looked at in the manner we consider a target price program. In summary, they find that market(s) m1+i with pre-existing ad-valorem taxes, subsidies, and loan rate programs need only be considered for government revenue effects, while price floor or ceiling programs require re-estimating equilibrium surplus effects, as well as government revenue effects. Market quota programs can be ignored, as surplus and government revenue effects offset.

$$- \int_{P^d_{m+i}(\eta^0)}^{P^d_{m+i}(\eta^1)} \tilde{q}_{m+i} \ . \tag{11}$$

Note that this surplus effect is not measured by the area between market m1 equilibrium curves. There is also a government effect (from deficiency payments) in market m+i from intervention in market m1. This government effect is:

$$\Delta T_{m+i} = D^a \cdot q_{m+i}(\eta^a) - D^b \cdot q^s_{m+i}(\eta^b), \tag{12}$$

where, for h ε [a b], $D^h = \max(0, \bar{P} - P^d_{m+i}(\eta^h))$.

For a market m1+j (j ε [0 L-1]) subject to a unit sales tax, the consequence of new regulation on government tax revenues is:

$$\Delta T_{m1+j} = \tau \times [(p(\eta^b) \cdot q(\eta^b) - (p(\eta^a) \cdot q(\eta^a)], \tag{13}$$

where τ is the unit sales tax rate.

In the following sections we will present the case that the supply of potash from Canada to the United States is very elastic, and the assumption of a perfectly elastic supply would not seriously compromise our empirical results. Consequently, we are left with the task of allocating ΔT_m between U.S. and Canadian producers. Also, as mentioned above, we focus on the primary potash using markets in the United States and determine that welfare impacts beyond these primary markets are of third order magnitude. Unless these markets produce outputs that have perfectly elastic demands, a share of the welfare impacts of the potash trade agreement is passed on to consumers of these outputs. Some of these consumers are foreign firms, and so an account of this "leakage" would finally give us an estimate of total social welfare impacts from USCTAP.

Measuring Price Impacts

The U.S. potash market is as depicted in figure 1. Due to the characteristics of the market, the supply of potash to the United States can reasonably be represented by a constant returns technology. Over three-quarters of total U.S. potash sales typically come from Canada, and average operating costs for various potash mines in Saskatchewan have a relatively large region of constant unit costs, although average costs are U-shaped (Olewiler, 1986, pp. 8-9). Potash production in Canada ranged from 59-73 percent of capacity from 1987 to 1992 (Prud'homme, 1993), allowing production to rise significantly before driving up costs. U.S. suppliers represent about one-fifth of the market, and supply potash inelasticly. With an aggregate supply curve that is horizontal within the relevant range of market activity, the impacts of the USCTAP can be obtained by estimating the change in the U.S. potash price.

A formal statistical analysis of the effects of the trade case might compare pre- and post-intervention potash prices, perhaps using a t test for a change in mean levels or other parametric or nonparametric methods. However, Box and Tiao (1975, p. 70) note that a t test is valid "only if the observations before and after the event of interest varied about means μ_1 and μ_2, not only normally and with constant variance but independently." Abraham (1987) illustrates the inadequacy of the usual

significance test for the difference between two means when a series is not independent. Time series data on potash prices violate these conditions, precluding the use of classical statistical tests.

A more appropriate method would be to conduct a counterfactual analysis, comparing what actually happened as a result of the antidumping case with a forecast of what might have occurred in its absence. While a significant share of the potash price increase was a direct result of the U.S. trade case against Canada, it would be incorrect to attribute the price increase entirely to the antidumping case. U.S. retail prices of most major fertilizer materials, including potash, were already increasing before the preliminary ruling by USDC in August of 1987. For example, after falling by 37, 21, and 26 percent, respectively, from spring 1984 levels, retail prices of anhydrous ammonia (AA), concentrated superphosphate (CS), and potassium chloride (PC) increased 7 percent from October 1986 to April 1987. The prices of AA and CS, which were not affected by the antidumping case, increased by an additional 20 and 18 percent, respectively, by April 1989.

We apply a multivariate ARIMA model, often referred to as a transfer function, to forecast what potash prices would have been in the absence of the antidumping case. Transfer functions are valuable in such instances because they can remove any potential autocorrelation which could obscure the intervention under study, allow for structural changes in parameters during pre- and post-intervention periods, and produce accurate forecasts (Larcker, Gordon, and Pinches, 1980). In the model, we incorporate the fact that the prices of most major fertilizer materials are highly correlated. For example, simple correlation coefficients between PC and CS, and between PC and AA stood at 0.96 and 0.84, respectively, over the period April 1960 - April 1987, the pre-intervention period. In the multivariate model, the potash price is specified as a function of the prices of AA and CS.

The impact of the antidumping case is isolated by employing the technique of intervention analysis, which is described by McCleary and Hay (1980, p. 142) as "a test of the null hypothesis that a postulated event caused a change in a social process measured as a time series." Intervention analysis is an extension of the autoregressive-integrated-moving-average (ARIMA) methods of time-series analysis popularized by Box and Jenkins (1976) and has been used for a variety of social science applications (Abraham, 1987; Cauley and Im, 1988; Fomby and Hayes, 1990; Kuchler and Vroomen, 1987; Wichern and Jones, 1977).

To forecast potash prices, we assume they would have continued to move in conjunction with the prices of AA and CS; that is, we assume that the high correlation between these prices would have continued to hold in the absence of the trade case. Many market factors affecting fertilizer prices are implicitly captured by using the prices of AA and CS as explanatory variables.

Transfer Function for Pre-intervention Data

The transfer function for the pre-intervention period is fit to biannual data for the period April 1960 - April 1987. From 1960 to 1976, U.S. retail fertilizer prices were reported during April and September. Retail prices were reported for March, May, October, and December during 1977-85. Since 1986, however, retail prices have only been available for April and October (U.S. Department of Agriculture, 1977-90). To form a continuous data set, we use the prices reported in April (1960-76 and 1986-87) or March (1977-85) for the spring season. The fall season is represented by the September price prior to 1977, while reported prices for October are used thereafter.

The identification process for a transfer function typically involves transforming the data to induce stationarity, prewhitening the series prior to inspecting the cross correlations used to check the dependencies between the series, and the fitting of an ARMA model to the residuals to generate a white noise process (see Vandaele, 1983). With this strategy, the transfer function was identified as:

$$PC_t = \alpha_1 AA_t + \alpha_2 CS_t + \frac{(1-\theta_1 B-\theta_2 B^2)}{(1-\phi_8 B^8)(1-B)} \varepsilon_t, \tag{14}$$

where B is the backshift operator such that $B^x Y_t = Y_{t-x}$, the α's are the coefficients on the explanatory variables, ϕ and θ are autoregressive and moving-average parameters, respectively, and $\{\varepsilon_t\}$ is a sequence of white noise.

Table 1 shows maximum-likelihood estimates and associated diagnostic statistics of the pre-intervention transfer function. Parameter estimates are statistically significant and lie within the bounds of stationarity and invertibility. Diagnostic checks do not reveal any model inadequacies and the residuals of the model do not differ from white noise as indicated by the Q-statistic of 8.63 (17.41), which is not significant when compared with a χ^2 statistic with 9 (21) degrees of freedom. In addition, the fit of the model is good, as indicated by the adjusted R^2 of 0.991.

Intervention Model

Intervention components are added to the transfer function to construct the full intervention model. The pre-intervention model is assumed to continue to be adequate for the post-intervention period, aside from the effect of the intervention. Intervention components are chosen to fit the observed or theoretical response of the time series under study. The theory of intervention developed in this analysis is based on the impact patterns discussed by Box and Tiao (1975). These patterns can be described by two characteristics, onset and duration. The onset of an intervention can be either abrupt or gradual, whereas the duration can be either permanent or temporary.

Visual inspection of the potash price series indicates that while the decision by Canadian producers to raise prices in response to the antidumping case was abrupt and permanent, the full effect of the event was not passed on in the form of higher retail prices until April 1988, the second post-intervention

Table 1--Transfer function for retail potash prices, April 1960 - April 1987

Variable/ coefficient	Estimated coefficients	Standard error	t-statistic	Q-statistic[1]
PC[2]				8.63
α_1	0.125	0.042	3.01	(17.41)
α_2	0.194	0.062	3.12	
θ_1	-0.350	0.141	-2.48	
θ_2	-0.366	0.135	-2.71	
ϕ_8	-0.508	0.193	-2.63	
		Adj. R^2 = .991		

[1] Value of Q-statistic based on 12 (24) residual autocorrelations.
[2] No intercept was used because it did not differ significantly from zero.

period (figure 2). This likely occurred because at least some of the potash sold by retailers during October 1987 was purchased at pre-trade case prices. Interventions of this type can be modeled by adding the following impulse response function to the model:

$$(\omega_0 - \omega_1 B)\ I_t, \tag{15}$$

where I_t is defined as a step function such that $I_t = 0$ prior to the event and $= 1$ thereafter. Under this formulation, the level of the series changes by the amount ω_0 during the first post-intervention period. In the following period, the change in the series grows to $\omega_0 - \omega_1$, which is the longrun impact (where $\omega_1 < 0$). Adding the intervention component in (2) to the pre-intervention transfer function (1) results in the full intervention model:

$$PC_t = (\omega_0 - \omega_1 B)\ I_t + \alpha_1\ AA + \alpha_2\ CS + \frac{(1-\theta_1 B-\theta_2 B^2)}{(1-\phi_8 B^8)(1-B)}\varepsilon_t. \tag{16}$$

Figure 2
U.S. retail price of potassium chloride (potash), April 1960 - April 1992

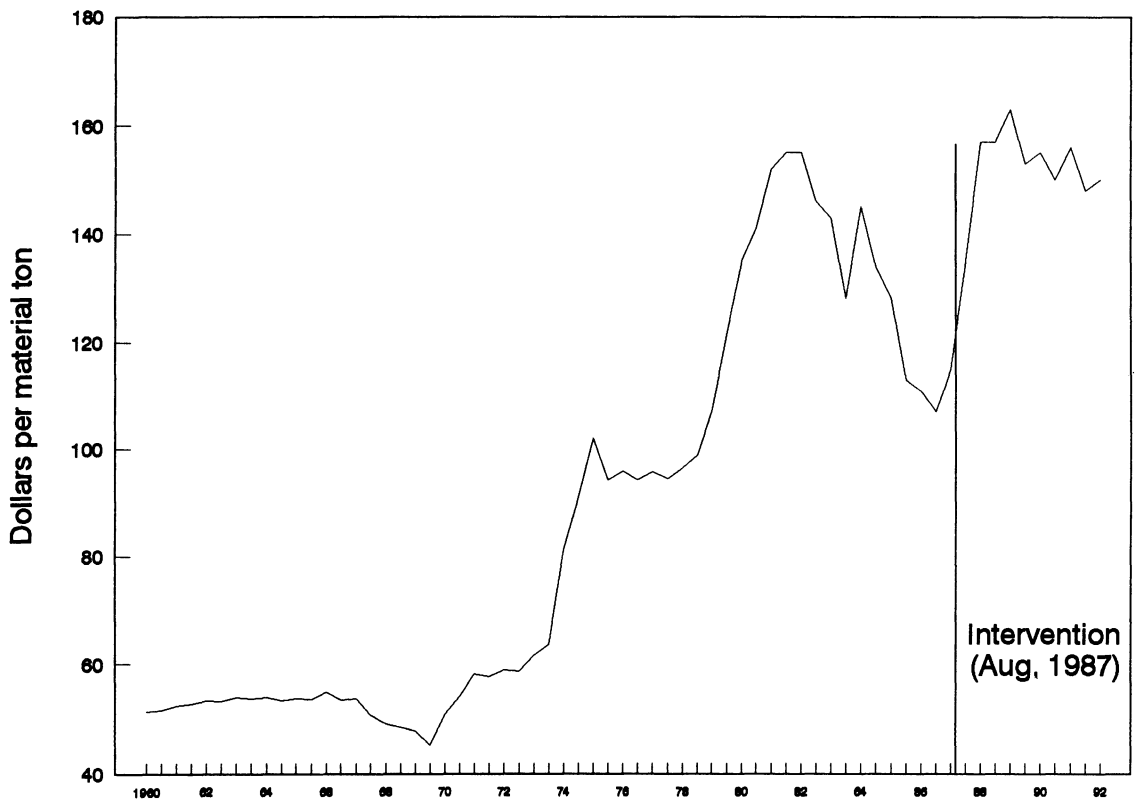


Table 2 shows maximum-likelihood estimates and associated diagnostic statistics of the intervention model. Parameter estimates are all statistically significant and residual autocorrelations reveal no serious model inadequacies. The estimates of α_1, α_2, θ_1, θ_2, and ϕ_8 are very similar to those obtained from the pre-intervention estimates, indicating that the transfer function continues to be adequate for the post-intervention period. In addition, the price series supports the hypothesis of the intervention; both impact parameters are of the expected sign and are significant at the 99-percent confidence level.

While a test of the null hypothesis was not in question, as the impact was visually obvious, intervention analysis provides precise estimates of the magnitude of the effect. The important results are the coefficients of the intervention components, $\omega_0 = 11.3$ and $\omega_1 = -16.9$. They indicate that the average retail price of PC increased by $11.3 per material ton during October 1987, the first observation after the USDC ruling, and by an average $28.2 during the period April 1988 through April 1992 (table 3).

In contrast, a simple comparison of pre- and post-intervention prices results in estimated increases of $20.0 and $39.3 per ton for the corresponding periods. Consequently, the impacts of the antidumping case would have been overestimated by nearly 42 percent using the latter approach.

Retail Supply and Demand Impacts

If potash prices had remained at pre-USCTAP levels, the quantity of potash demanded would have been greater than observed levels. Given P^0 and observed potash prices (P^1) and quantities (Q^1) at the retail level, the levels potash use might have reached in the absence of USCTAP can be computed using the equation:

$$Q^0 = \frac{Q^1}{1 + \varepsilon_P^D \times \frac{P^1 - P^0}{P^0}}, \tag{17}$$

where ε_P^D is the price elasticity of demand for potash in the United States. A number of previous studies recently summarized by Picketts and others (1991) have estimated this elasticity to be between -0.36 and -0.53. Following Picketts and others, we use an elasticity of -0.4 to simulate the levels potash use might have reached in the absence of the trade case.

Data on fertilizer use are reported on a fertilizer year (FY) basis that covers the period July-June (Tennessee Valley Authority, 1988-90). In addition, during FY's 1988-90, an average 65 percent of all fertilizer was purchased during the July-December period, with the remainder being purchased during January-June (Tennessee Valley Authority). By applying these weights to data on U.S. potash use, the annual data can be divided into 6-month intervals for the period July 1987-June 1990. Using the October retail price increases to represent an average for the July-December period and the April increases to represent averages for January-June, we compute potash use levels under a no USCTAP scenario using equation 21 (table 3).

Results

Our analysis estimates the equilibrium potash price and quantity response to the USCTAP in the U.S. retail market. From our model presented in section two, we need only carry out simple algebraic and geometric calculations to trace out economywide impacts. A further breakdown of impacts by commodity markets will facilitate estimates of impacts passed on to outside economies, as well as government revenue effects in the farm commodity markets. This provides us with change to net social welfare.

Table 2--Intervention model for retail potash prices, April 1960 - April 1992

Variable/coefficient	Estimated coefficients	Standard error	t-statistic	Q-statistic[1]
PC[2]				7.30
α_1	0.142	0.034	4.20	(19.34)
α_2	0.184	0.055	3.36	
θ_1	-0.361	0.133	-2.71	
θ_2	-0.355	0.127	-2.79	
ϕ_8	-0.445	0.139	-3.20	
ω_0	11.337	2.969	3.82	
ω_1	-16.865	2.950	-5.72	
		Adj. R_2 = 0.994		

[1] Value of Q-statistic based on 12 (24) residual autocorrelations.
[2] No intercept was used because it did not differ significantly from zero.

Table 3--Estimated increase in U.S. potash price resulting from U.S. - Canadian trade dispute, 1988-92

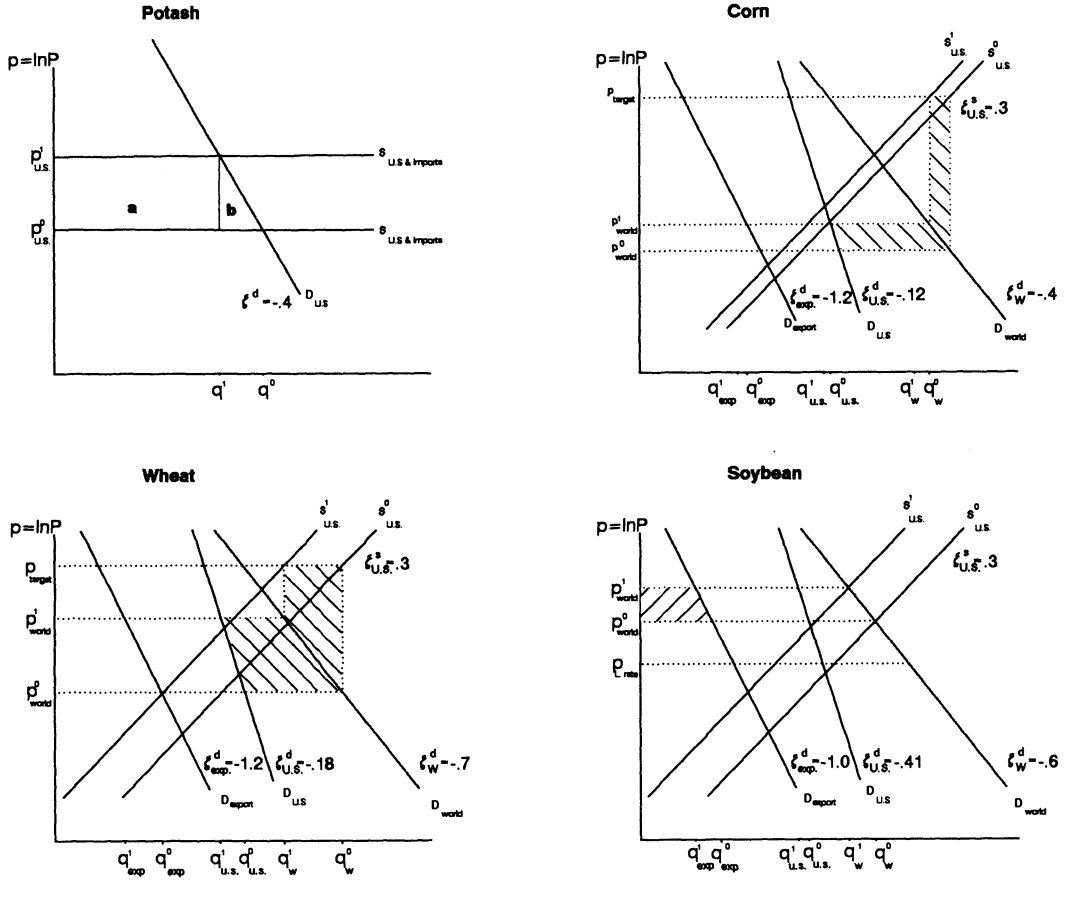
Period	Actual price	Intervention model forecast	Projections without trade case	Quantity impacts Q^0	Quantity impacts Q^1
	--------Dollars per material ton--------			--Nutrient tons K_2O--	
December 1987	135	134.2	122.9	1,701.8	1,634.8
July 1988	157	156.6	128.4	3,664.4	3,337.9
December 1988	157	157.2	129.0	1,741.7	1,590.5
July 1989	163	165.3	137.1	3,513.0	3,247.5
December 1989	153	155.9	127.7	1,857.6	1,710.4
July 1990	155	153.0	124.8	3,866.7	3,492.4
December 1990	150	152.2	124.0	1,794.6	1,644.1
July 1991	156	153.1	124.9	3,728.5	3,357.1
December 1991	148	148.7	120.5	1,825.2	1,658.6
July 1992	150	151.5	123.3	3,707.3	3,386.5

Gains to Potash Producers and Related Industries

From the model (equations 9 to 13), and figure 3, we calculate the total gain to industries that bring potash to market as area "a" under the potash demand curve between p^0 and p^1. From our counterfactual analysis, we have estimates for p^0 for years 1987/88 to 1991/92. By combining these estimates with the observed prices (p^1) and quantities (q^1), we can compute area "a" for each year as the product $q^1 \times (p^1 - p^0)$. The results, reported in table 4, represent the net annual benefit of USCTAP to industries bringing potash to market.

These totals must be allocated between U.S., Canadian, and "other foreign" potash suppliers. Gains are allocated to domestic potash producers by computing their domestic sales as a proportion of total

Figure 3
Equilibrium impacts of USCTAP in primary markets



U.S. consumption. U.S. producers averaged 20.4 percent of the total market during the 1987/88 through 1991/92 period. The remaining domestic sales are then attributed to U.S. potash imports, which can be separated into Canadian and "other." Potash from Canada accounted for an average of 88 percent of total U.S. imports from 1987/88 through 1990/91 (Vroomen and Taylor, 1993), making the Canadian producers the big winners.

Distribution of Costs to Potash Users and Related Industries

Potash users must pay the full amount of the gain to producers, plus the amount depicted by area "b" in figure 3. This area is equal to $(q^0 - q^1)/2 \times (p^1 - p^0)$, or the Harberger triangle. These estimates, along with total annual costs to potash users (area "a" + "b"), for years 1987/88 through 1991/92 are reported in table 5.

A share of the costs to potash users is passed on to their customers, including a significant export market. The primary users of potash are corn, soybean, and wheat producers.[8] These markets account for approximately two-thirds of total U.S. potash use (Vroomen and Taylor, 1993).

Because domestic demand for these products is inelastic, much of the cost is passed on to the final consumers.

Table 4--Gains to potash suppliers

Year	Total = Area "a"	United States	Canada	Other foreign
		Million 1987 dollars		
1987/88	191.4	39.1	134.1	18.3
1988/89	205.7	42.0	144.1	19.6
1989/90	227.7	46.5	159.5	21.8
1990/91	215.9	44.1	151.3	20.6
1991/92	191.8	39.1	134.4	18.3

Table 5--Total costs to potash users

Year	Harberger triangle (Area b)	Total cost to users (Area a + b)
	Million 1987 dollars	
1987/88	8.4	199.9
1988/89	8.9	214.6
1989/90	11.5	239.2
1990/91	11.3	227.3
1991/92	9.3	201.1

[8]Although cotton producers use an appreciable amount of potash, the average cost of potash per unit of cotton production is so small that cotton is considered in the group we denote as "other users."

Figure 3 (not drawn to scale) depicts the distributional effects. All elasticity assumptions in these markets appear in the figure. All export demand elasticities are the median reported values for longrun elasticities presented in Gardiner and Dixit (1987). The U.S. supply and world demand elasticities for corn, wheat, and soybeans are those used in Gardner (1990). U.S. demand elasticities are computed by the formula:

$$\xi^d_{U.S.} = \frac{\xi^d_W - \%exported \times \xi^d_{exp}}{\%consumed\ in\ U.S.} \tag{18}$$

We note here that our depiction of the corn and wheat markets implicitly incorporates the effects of acreage reduction and set-aside programs because the elasticity assumptions we use reflect supply and demand responses that occur with such programs in place. To obtain our estimates of government revenue effects, we assume the percentage quantity response for both program and nonprogram output is identical.

As the primary potash user, the corn market is most affected. Based on average rates of potash use for corn, we estimate an increase in production cost of 1.5 cents per bushel for 1987/88 due to USCTAP. Similar calculations for other years and for soybean and wheat are reported in table 6. As a result, the equilibrium supply curve in each crop market shifts back to S^1, reflecting the increase in production costs. Domestic and export demand curves are depicted for the three commodities.

We observe the USCTAP outcome, and have calculated the price effect for the non-USCTAP result. We are after the value for q^0 for each crop. From the USCTAP outcome, removal of the trade agreement causes total U.S. supply curves for the three commodities to shift down vertically by the per unit reduction in production costs, as reported in table 6. For corn and wheat, the binding target price remains after removing the trade intervention,[9] so suppliers will expand production by the product of the percent price increase required to return from the new per unit production cost at q^1 back to the target price, and the elasticity of supply times q^1, or:

$$q^0_w = \frac{p_{target} - mc(q^1_w)}{p_{target}} \times \xi^s \times q^1_w + q^1_w, \tag{19}$$

where mc() is the marginal cost of production at the USCTAP level without the USCTAP in effect. This gives the quantity supplied in absence of a trade agreement, with the target price still binding. We can use this information to calculate the market clearing world price in the absence of the trade agreement. We calculate the market clearing price as follows:

$$p^0_{world} = \frac{q^0_w - q^1_w}{q^1_w} \times \xi^d_{world} \times p^1_{world} + p^1_{world}. \tag{20}$$

For soybeans we have a different problem, since there is no target price program. We observe equilibrium price and quantity, p^1 and q^1, which are also the coordinates of a point on the equilibrium demand curve for soybeans. We can infer the coordinates of a point on the equilibrium supply curve,

[9]Because of the high participation rates for these programs, we expect the pre- and post-intervention average price to be the same.

Table 6--Increased production costs to major potash users

Year	Increased cost per bushel			Total cost increase			
	Corn	Soybeans	Wheat	Corn	Soybeans	Wheat	Other[1]
	---1987 cents per bushel---			----------Million 1987 dollars----------			
1987/88	1.4	1.4	0.5	100.6	27.9	11.0	60.4
1988/89	1.0	1.3	0.5	51.3	20.6	9.9	132.8
1989/90	1.1	1.2	0.4	83.3	23.1	8.3	124.6
1990/91	1.0	0.9	0.5	77.8	18.0	13.5	117.9
1991/92	0.7	0.8	0.3	55.9	16.5	6.4	122.3

[1] Computed as the area "a + b" less the increased potash costs for corn, soybeans, and wheat.

S^0, by noting that the difference in price between S^0 and S^1 at q^1 is equal to the input cost for potash per unit of output, as reported in table 6. We know the functional form of soybean supply and demand curves to be:

$$p^s_{world} = \left[\frac{q}{a}\right]^{\frac{1}{\xi^s_{world}}}, \qquad p^d_{world} = \left[\frac{q}{b}\right]^{\frac{1}{\xi^d_{world}}}. \tag{21}$$

Because we know the supply and demand elasticities, and the coordinates of a single point on each curve, we simply solve for "a" and "b", set supply equal to demand, and solve for q^0 and p^0. This gives the quantity supplied and demanded in the absence of the trade agreement. Having estimated prices p^0 and observed prices p^1 for the three commodities for years 1987/88 through 1991/92, the change in area under the domestic and export demand curves can be estimated using procedures identical to those used to calculate area's "a" and "b" in the potash market. This result indicates how much of the cost of USCTAP is passed on to the customers of potash users, and how much of the cost is directly passed on to U.S. trading partners.

Much of the disaggregated data required in making the input cost calculations for the "other" commodities does not exist. However, supply and demand elasticities for "other" potash users are generally in the range of the three commodities considered. These "other" crops use one-third of the potash, and we infer that costs are passed on to their customers at identical percentages as that of the three major crops, or one-half the amount of the total cost passed on by corn, wheat, and soybean producers. Table 7 reports the full results for each of the years analyzed.

The change in government payments is calculated for the corn and wheat programs. Costs are calculated as $[(p^T-p_1)q_1-(p^T-p_0)q_0]xq^T$, where q^T is the percentage of total production enrolled in the relevant commodity program, and is assumed to remain constant. The results for 1987/88 through 1991/92 are reported in table 8.

Table 7--Potash user costs passed on to secondary markets

Crop	1987/88	1988/89	1989/90	1990/91	1991/92
			Million 1987 dollars		
Corn:					
Domestic	6.58	5.58	6.36	5.91	4.91
Export	1.87	2.20	2.62	1.69	1.23
Soybeans:					
Domestic	6.11	5.08	4.98	4.00	3.77
Export	3.85	2.34	2.49	1.74	1.90
Wheat:					
Domestic	0.70	0.99	0.77	0.93	0.58
Export	1.02	1.44	0.95	0.73	0.65
Other:					
Domestic	6.69	5.88	6.01	5.42	4.63
Export	3.37	2.99	3.04	2.08	1.89
Total:					
Domestic	20.08	17.63	18.17	16.27	13.88
Export	10.11	8.96	9.10	6.24	5.67

Table 8--U.S. government cost savings

	Reduction in government payments to:	
Year	Corn producers	Wheat producers
	Million 1987 dollars	
1987/88	14.01	2.28
1988/89	8.00	1.83
1989/90	9.06	1.41
1990/91	8.49	2.75
1991/92	5.85	1.25

Conclusions

This report has presented estimates of welfare impacts of the U.S./Canadian trade agreement on potash, based on an application of a three-sector open economy model that incorporates two important features. The assumption of a free-market economy prior to intervention was replaced with a model reflecting the primary features of status quo U.S. farm policy. In addition, the economy is open, such that equilibrium is determined in world markets, while inputs and outputs flow between the United States and its trading partners.

The primary impacts of the trade case were obtained by conducting a counterfactual analysis, comparing what actually happened with potash prices and quantities as a result of the trade case to estimates of prices and quantities in its absence. This was accomplished using a multivariate transfer function. Impacts in the primary potash-using markets (corn, soybeans, and wheat) were measured using supply/demand equilibrium model simulation.

The average annual distributional impacts of USCTAP are depicted in figure 4. The impacts are distributed as follows. From 1987/88 through 1991/92, USCTAP produced gains (in 1987 dollars) to industries bringing potash to the U.S. market of $1.03 billion. Of this total, $723 million went to Canadian producers, $211 million went to U.S. producers, and $99 million went to "other" foreign producers. U.S. potash users bore the cost of these gains, plus an additional cost (the Harberger triangle), totaling $1.08 billion. However, $126 million of this cost was passed on to their customers, including $40 million passed on to U.S. trading partners. Deficiency payment outlays are $55 million lower under USCTAP, but only $22 million of this represents a net social savings. The remainder is financed through higher prices for program crops.

Figure 5 depicts the total net social welfare impact, along with total costs passed on to U.S. trading partners. The net effect of USCTAP to U.S. firms, households, and the government over the 1987/88 through 1991/92 period is a loss of $815 million (1987 dollars) in social welfare. Estimated results reveal the importance of considering a model of sufficient generality in order to present meaningful welfare analysis. Estimates show that (1) a large percentage of both gains and losses resulting from USCTAP are passed on to U.S. trading partners, (2) more than 14 percent of the higher costs born by potash users are passed on to their customers, and (3) considerable government savings result from reductions in outlays for U.S. farm commodity programs.

In market-oriented open economies, the consequence of regulating markets on net social welfare is not always obvious. In an integrated market with multiple regulations, a new regulation can diminish or enhance the deadweight loss associated with other policies or externalities. Also, because the economy is open, some of the costs of new regulation can be passed on to trading partners, even if a new regulation does not directly involve trade.

Figure 4
Distribution of gains and losses

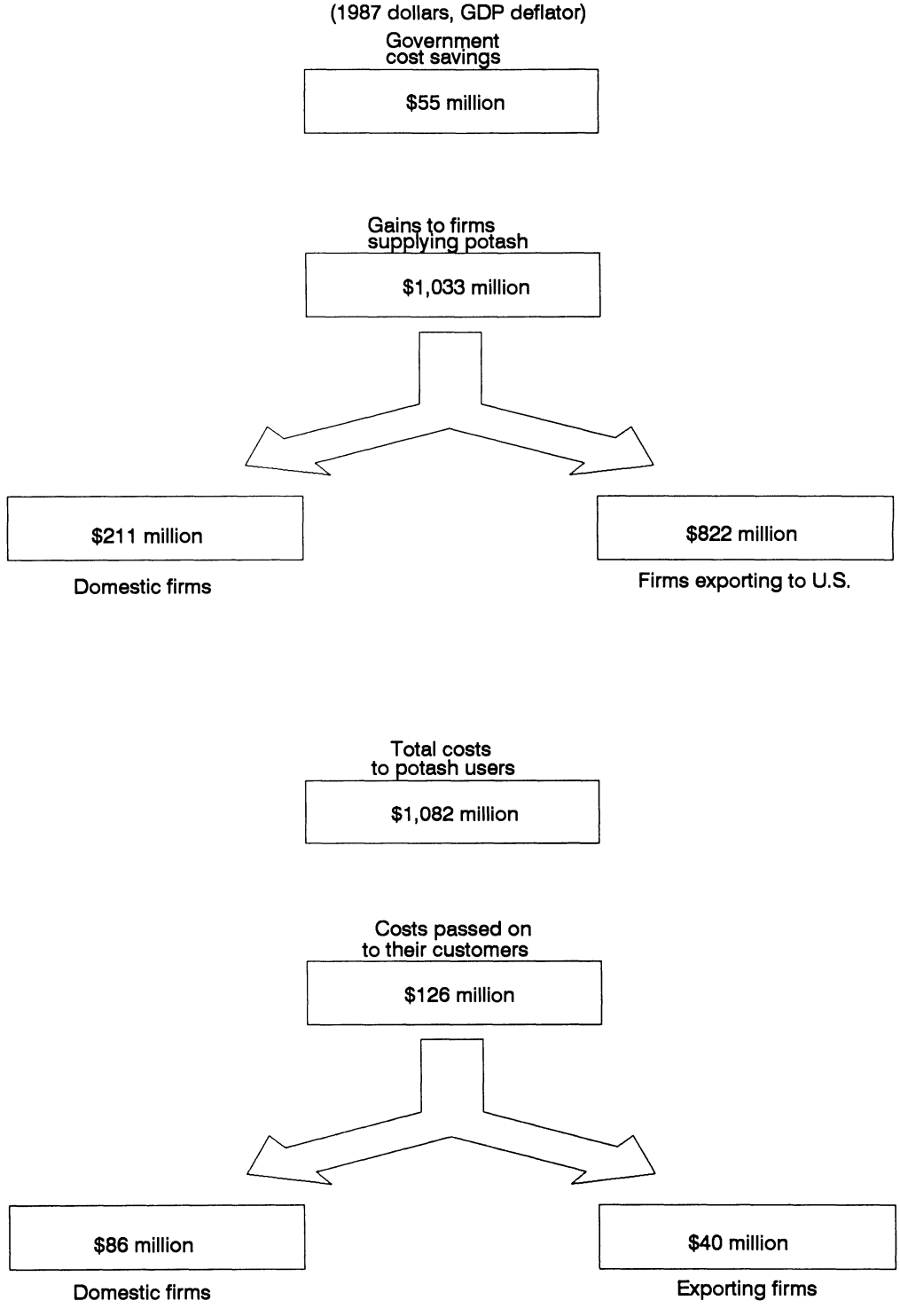
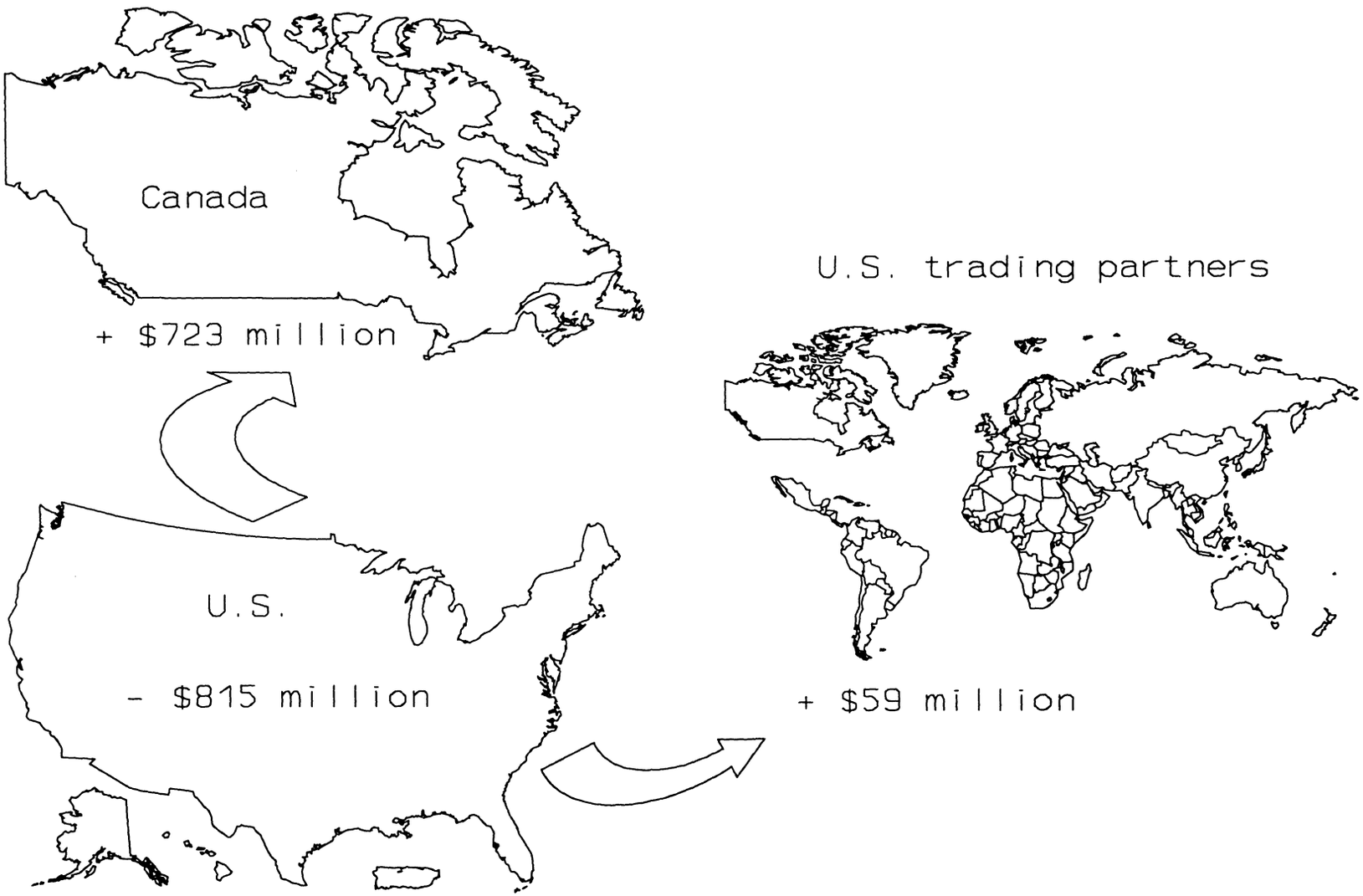


Figure 5
Net social welfare costs to United States, and gains to U.S. trading partners



References

Abraham, B. "Application of Intervention Analysis to a Road Fatality Series in Ontario," *Journal of Forecasting*, 6 (1987), 211-219.

Box, G.E.P., and G.W. Jenkins. *Time Series Analysis: Forecasting and Control.* San Francisco: Holden Day, 1976.

Box, G.E.P., and G.C. Tiao. "Intervention Analysis with Applications to Economic and Environmental Problems," *Journal of the American Statistical Association*, 70 (1975), 70-79.

Bullock, D.S. "Welfare Implications of Equilibrium Supply and Demand Curves in an Open Economy," *American Journal of Agricultural Economics*, 75 (1993) 52-58.

Cauley, J. and E.I. Im. "Intervention Policy Analysis of Skyjackings and Other Terrorist Incidents," *The American Economic Review*, 78 (1988), 27-31.

Fomby, T.B., and K.J. Hayes. "An Intervention Analysis of the War on Poverty: Poverty's Persistence and Political-Business Cycle Implications," *Journal of Econometrics*, 43 (1990), 197-212.

Gardiner, W.H., and P.M. Dixit. *Price Elasticity of Export Demand: Concepts and Estimates.* FAER No. 228, U.S. Dept. Agr., Econ. Res. Serv., 1987.

Gardner, B.L. *The Economics of Agricultural Policy.* New York: Macmillan Publishing Company, 1987.

_____. "The Why, How, and Consequences of Agricultural Policies," in *Agricultural Protectionism In The Industrialized World.* Washington, DC: Resources For The Future, 1990.

Harberger, A. "Three Basic Postulates for Applied Welfare Economics: An Interpretive Essay," *Journal of Economic Literature*, 9, No. 3 (Sept. 1971), 785-97.

Just, R.E., D. Hueth. "Multimarket Welfare Measurement," *American Economic Review*, 69, No. 5 (December 1979), 947-54.

Just, R., D. Hueth, and A. Schmitz. *Applied Welfare Economics and Public Policy.* Englewood Cliffs, NJ: Prentice-Hall, 1982.

Kuchler, F., and H. Vroomen. "Impacts of the PIK Program on the Farm Machinery Market," *The Journal of Agricultural Economics Research*, 39 (1987) 2-11.

Larcker, D.F., L.A. Gordon, and G.E. Pinches. "Testing for Market Efficiency: A Comparison of the Cumulative Average Residual Methodology and Intervention Analysis," *Journal of Financial and Quantitative Analysis*, 15 (1980), 267-287.

McCleary, R., and R.A. Hay. *Applied Time Series Analysis for the Social Sciences*, Beverly Hills: Sage, 1980.

Olewiler, N. *The Potash Corporation of Saskatchewan: An Assessment of the Creation and Performance of a Crown Corporation.* Ottawa, Ontario: Economic Council of Canada Pub. No. 303, April 1986.

Picketts, V.A., A. Schmitz, and T.G. Schmitz. "Rent Seeking: The Potash Dispute between Canada and the United States," *American Journal of Agricultural Economics*, 73 (1991) 255-265.

Prud'homme, M. "Potash," *1992 Canadian Minerals Yearbook*. Department of Energy Mines and Resources, Ottawa, Canada, March 1993.

Purcell, E.J. *Calculus With Analytic Geometry*, Englewood Cliffs, NJ: Prentice-Hall, Inc., 1978.

Tennessee Valley Authority, Economics and Marketing Staff. *Commercial Fertilizers*, Annual issues, 1988-90.

U.S. Department of Agriculture, National Agricultural Statistics Service. *Agricultural Prices*, various annual issues, 1977-1990.

U.S. Department of Commerce, International Trade Administration. "Potassium Chloride from Canada: Preliminary Determination of Sales at Less Than Fair Value," Inv. A-122-701, Aug. 1987.

Vandaele, R.A. *Applied Time Series Analysis and Box-Jenkins Models*, New York: Academic Press, Inc, 1983.

Vroomen, H., and H. Taylor. *Fertilizer Use and Price Statistics, 1960-91*. SB-851, U.S. Dept. Agr., Econ. Res. Serv., Jan. 1993.

Wichern, D.W., and R.H. Jones. "Assessing the Impact of Market Disturbances Using Intervention Analysis," *Management Science*, 24 (1977), 329-337.

U.S. Department of Agriculture
Economic Research Service

SUMMARY OF REPORT

Land Type, Investment Cost Subsidy Affect Adoption of Pollution Controls

Number 35, September 1993

Contact: Margriet F. Caswell, 202-219-0434

Pollution from agricultural activity depends on the agricultural practices or technologies that farmers employ. Adoption of less polluting practices can be induced by a variety of policy instruments. Cost-sharing by the government to reduce the costs of technology adoption and/or implementation for producers is an instrument widely used by the U.S. Department of Agriculture. This report examines the problem of designing economically efficient cost-sharing programs. The adoption decision for a farm is based on a comparison of the relative profitability of the existing technology and a new, less polluting one where the profitability of each technology depends on land quality. The problem for government is to determine the optimal subsidy rates that will induce a level of adoption sufficient to achieve some pollution goal. A benchmark (or first best) solution to the pollution problem serves as a reference against which to compare the optimal cost-sharing policy. The authors also examine the importance of specifying the land on which a technology should be used and of varying subsidy rates across inputs.

This highly technical analysis is contained in a new report from USDA's Economic Research Service, *Equilibrium Effects of Agricultural Technology Adoption: The Case of Induced Output Price Changes.*

New technologies often are developed and introduced to improve agricultural productivity. The adoption of a new technology may not encompass an entire sector, however, due to differences among farms with respect to environmental assets such as soil quality or topographical uniformity. Policies designed to encourage the use of a pollution-reducing technology may have to be targeted to farms having certain resource characteristics to be cost effective.

The widespread adoption of new agricultural technologies may affect output supply for the sector. An increase in overall yield will lower the equilibrium crop price that farmers receive for their output. The change in revenues then will affect profits which, in turn, will affect the incentive to adopt the new technology. The strength of this feedback effect will depend on the responsiveness of product demand to the change in price. The authors used a numerical simulation to show the effect of an increase in input costs on output price and supply, profits, input demand, and technology use. In the irrigation example presented in the report, an increase in water costs shows how the adoption of low-volume irrigation systems would be affected and what the subsequent feedback effects would be. The effects of the cost change depend on the price elasticity of demand for the crop. The authors introduced government policies to maintain output levels and income to the model and compare their effects. A production goal can be met, but at the expense of industry profits. An alternative policy to maintaining aggregate output is to support a level of industrywide net income or profits. Although aggregate profits may be held constant, the distribution of profits between adopters and nonadopters becomes increasingly disparate.

Some changes are likely when a new technology is introduced, and some of the changes may have negative effects. The study shows that the introduction of a conserving technology does not necessarily reduce input use. The example in the study shows that low-volume irrigation systems may greatly increase yields on farms that previously used flood methods. Although the water-use efficiency of the new technology is better (defined as the amount of water used per unit of output), the large increase in yield results in the total amount of water being greater. This result depends on the responsiveness of crop growth to the technology.

To Order This Report...

The information presented here is excerpted from ***Equilibrium Effects of Agricultural Technology Adoption: The Case of Induced Output Price Changes,*** TB-1823, by Margriet F. Caswell and Robbin A. Shoemaker. The cost is $9.00.

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SUMMARY OF REPORT

Restricting Chemical Use on the Most Vulnerable Cotton Acreage Can Protect Water Quality With Only Minor Effects on Cotton Yields and Prices

Number 6, January 1993

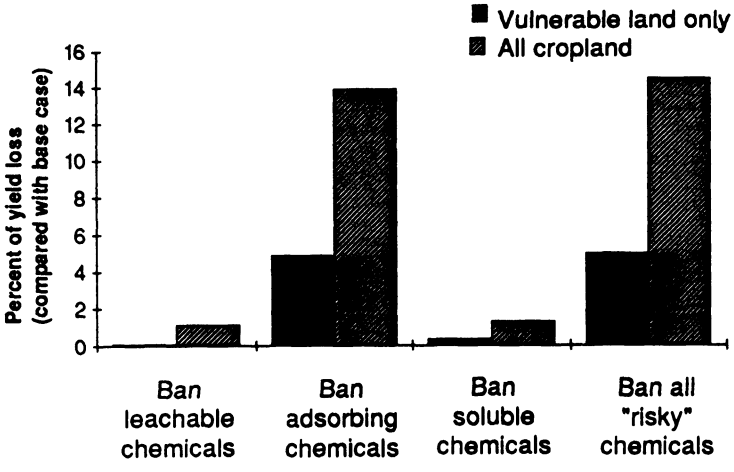
Contact: Stephen R. Crutchfield, (202) 219-0444.

Environmental damage to surface and ground water posed by cotton farming may be reduced, with only limited effects on yields and prices, if restrictions on agrichemical use or production are applied to just those acres most vulnerable to water-quality problems. The most widespread potential damage is from nitrates in fertilizer that can pollute ground water and pesticides that can contaminate surface water.

Production of cotton appears less likely than other crops to cause erosion-induced water-quality problems because cotton acreage is not the major source of cropland erosion in most regions. Widespread restrictions on the use of chemicals likely to leach, dissolve in cropland runoff, or attach to eroding soils may reduce the risk of water-quality degradation, but may also raise cotton prices by reducing yields. These conclusions flow from USDA's 1989 Cotton Water Quality Survey that gathered data on cotton agricultural chemical use and related production practices and resource conditions in 14 cotton States. Data gathered on the use of fertilizers, herbicides, insecticides, and other agricultural chemicals were analyzed to assess the potential water-quality problems that may be associated with cotton production.

Yield losses from chemical restrictions on cotton acreage

Yield losses are minimized if chemical restrictions are targeted to only cotton acreage at greatest water-quality risk.



Widespread Restrictions Could Raise Cotton Prices

The study's results highlight the importance of targeting pollution-prevention programs to attain the most cost-effective environmental protection strategies. Restricting the use of environmentally damaging chemicals on all cotton acreage could reduce the overall potential for water-quality impairment, but could raise cotton prices by as much as 31 percent. More specific chemical-use restrictions, targeted to acreage considered at greatest water-quality risk, could achieve nearly the same level of environmental protection, but would limit price increases and reduce yield losses. Modifying production practices to reduce soil erosion could generate $25 million in economic benefits by reducing sedimentation in surface water systems.

To Order This Report...

The information presented here is excerpted from ***Cotton Production and Water Quality: Economic and Environmental Effects of Pollution Prevention,*** AER-664, by Stephen R. Crutchfield, Marc O. Ribaudo, LeRoy T. Hansen, and Ricardo Quiroga. The cost is $8.00.

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