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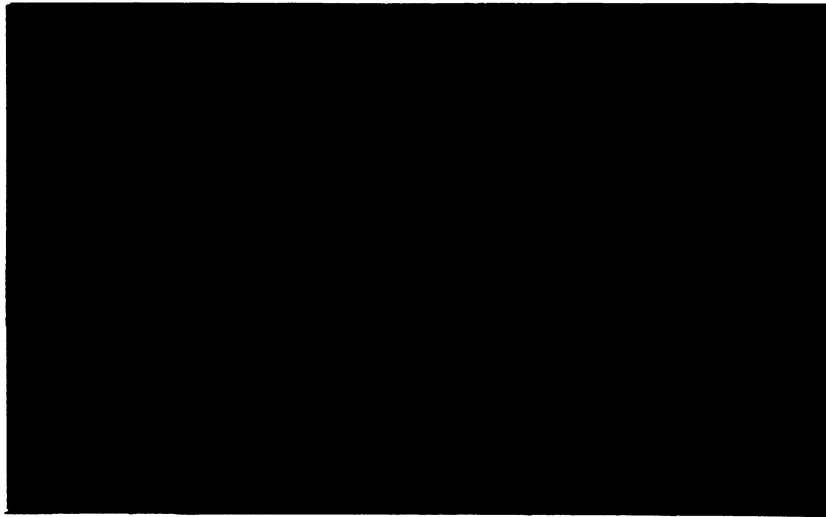
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National Agricultural Policies in a  
Free-Trade Area

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## National Agricultural Policies in a Free-Trade Area

During the negotiations preliminary to the North American Free Trade Agreement (NAFTA), it became obvious that the agricultural policies and institutions of both the United States and Mexico could act as trade impediments. Mexican fruit and vegetable growers, for example, were particularly concerned that the minimum-quality provisions of U.S. fruit and vegetable marketing orders might act as nontariff barriers to trade. While it is now well recognized that domestic agricultural policies may impede trade in a free-trade area, relatively little attention has been devoted to the closely related issue of how best to achieve national agricultural policy goals within the confines of a free-trade area. To my knowledge, only one study (Josling) has specifically considered this issue. However, a fundamental proviso of NAFTA is its "national-treatment" obligation (The Government of the United States et al.): Goods from one NAFTA country imported into another cannot be the object of discrimination. Because domestic agricultural policies frequently discriminate against products of foreign origin and have traditionally been reinforced by explicit trade barriers (e.g., the EC variable-levy system and the U.S. Section 22 authority), national treatment may curtail the ability of traditional agricultural policy tools to achieve national policy goals. For example, traditional price-support schemes would support prices to all producers within the free-trade area if operated under national treatment.

This paper is a preliminary attempt to analyze national agricultural policy design within the context of a free-trade area. As such, the analysis is kept purposely simple: I consider only a single agricultural commodity in a two-country world. And of necessity, therefore, many potentially interesting issues that an appropriately designed national agricultural commodity policy should face are ignored: cross-commodity effects, what to do with regard to third

countries not party to the free trade agreement, coordinating agricultural policy with monetary and fiscal policy, and many others. While these issues are important, it should be noted that most traditional agricultural-policy models also routinely ignore them (Gardner).

The analytical approach I use is borrowed from the emerging literature on mechanism design as applied to agricultural-policy analysis (Fudenberg and Tirole; Lewis et al.; Chambers). In formulating specific agricultural-policy goals, I only consider constrained Paretian outcomes. Because any optimally designed agricultural policy would hopefully be constrained Paretian, the analysis thus should be more general than an analysis hinging upon a single (e.g., income support) or multiple (e.g., income support and consumer subsidization) policy goals. Moreover, the analysis is not restricted to any particular set of traditional policy implements (e.g., target prices, loan rates). Instead following the established practice of the mechanism-design literature, I concentrate on characterizing the general class of constrained Paretian mechanisms to preserve as much generality as possible. As Chambers has shown, all traditional policy implements are special cases of more general mechanisms.

In what follows, I first present the basic model. After that I develop some basic principles of mechanism design as they apply to the current problem. Next the constrained Paretian problem that the paper considers is introduced and is shown to be decomposable into a two-stage optimization problem. The first stage of this optimization problem is a simple linear program. A set of simple graphical tools is developed for analyzing this first-stage problem and then used to show that two different types of outcomes can occur: the unconstrained Paretian outcome, and a constrained Paretian outcome. Optimal mechanisms are then characterized under a variety of assumptions on the cost structure of the model. In the next section of the paper, I

discuss an actual mechanism that can implement the optimal allocation and discuss some limitations of the model. The final section concludes.

## The Model

There are two countries which, for mnemonic simplicity, I shall refer to as Mexico and the United States. In what follows, variables and functions specific to the United States will be denoted by subscript "1", variables and functions specific to Mexico will be denoted by subscript "2". There is a single commodity that is produced in both countries. The representative producer's cost structure in country  $i$  is described by the cost function  $C_i: \mathbb{R}_+ \rightarrow \mathbb{R}_+$ :

$$C_i = C_i(q),$$

which is twice continuously differentiable and satisfies  $C'_i > 0$  and  $C''_i > 0$  where primes on functions denote derivatives. Two alternative assumptions on the cost structures are useful:

**Assumption 1:**  $C'_2(q) > C'_1(q)$  for all  $q \in \mathbb{R}_+$  and  $C_i(0) = 0$  ( $i = 1, 2$ ).

**Assumption 2:**  $C'_1(q) > C'_2(q)$  for all  $q \in \mathbb{R}_+$  and  $C_i(0) = 0$  ( $i = 1, 2$ ).

Assumption 1 says that the United States always has a strict cost advantage over Mexico in producing the agricultural commodity, and that no country experiences any fixed cost.

Assumption 2 gives the cost advantage to Mexico.

For analytic simplicity, assume that the commodity is only consumed in the United States and that US evaluation of the commodity is given by  $U: \mathbb{R}_+ \rightarrow \mathbb{R}_+$ :

$$U = U(q_1 + q_2),$$

where  $U$  is twice continuously differentiable with  $U' > 0$  and  $U'' < 0$ . Two things should be noted about this specification. First, it assumes that the agricultural commodity produced in the United States and the agricultural commodity produced in Mexico are perfect substitutes in consumption. US consumers are, therefore, indifferent to the source of supply. Second, in line

with traditional farm-policy analyses, which rely on consumer surplus as a measure of consumer welfare (Gardner; Alston and Hurd), income and cross-commodity effects are ignored.

My basic presumption is that Mexican interests do not enter directly into the US welfare calculus. The general policy problem, therefore, is: The US government must design a mechanism which allocates all of the commodity produced in the United States and Mexico to US consumers. This mechanism is described by two pairs  $(B_i, q_i)$  ( $i = 1, 2$ ) where  $B_i$  represents the payment to producers who produce the amount  $q_i$ . Designing the mechanism is equivalent to designing a nonlinear pricing schedule for the amount of the commodity sold, and thus any traditional policy tool or, more realistically, any combination of traditional policy tools plus market structures can be represented as a specific mechanism (Chambers). A familiar mechanism is the free-market, price mechanism, where the equilibrium price,  $p$ , equates consumer marginal willingness to pay with producer marginal cost in each country, i.e.,

$$U'(q_1 + q_2) = C'_1(q_1) = C'_2(q_2) = p.$$

For this latter mechanism,  $B_i = pq_i$ .

In designing the agricultural mechanism, the United States is assumed to face three constraints: First, it cannot force Mexican producers to supply the agricultural commodity to the United States; Mexican producer participation in the allocation mechanism must be voluntary. The payment to Mexican producers,  $B_2$ , therefore must be large enough to at least their cover costs:

$$B_2 - C_2(q_2) \geq 0. \tag{1}$$

Second, this mechanism must meet the "national-treatment" obligation of NAFTA. Here, I interpret "national treatment" to mean that the mechanism cannot discriminate overtly against products on the basis of national origin, and that a producer's returns can only depend upon the



amount produced and sold. That is, Mexican and US producers producing the same amount should receive the same payment. This represents a minimal requirement for national treatment, and one could certainly argue that further restrictions might be necessary. What that implies, however, is that more restrictions in addition to those developed below may be necessary to meet national treatment. Regardless, the national-treatment restrictions developed here still must apply. National treatment, thus requires that if the United States government designs a mechanism that allocates different production levels to US and Mexican producers, and differing payments as well, then the Mexican producers must be free to choose to produce and sell the same allocation for the same amount as US producers. Moreover, Mexican producers must freely choose to produce and sell the amount intended for them. The converse applies for US producers. Mathematically, this constraint is reflected by the two inequalities:

$$B_1 - C_1(q_1) \geq B_2 - C_1(q_2), \quad (2)$$

$$B_2 - C_2(q_2) \geq B_1 - C_2(q_1). \quad (3)$$

which I shall refer to as the 'national-treatment constraints'. Expression (2) guarantees that US producers are always at least indifferent between the allocation intended for them and the Mexican allocation. Similarly, expression (3) guarantees that Mexican producers always at least weakly prefer their allocation to the US allocation. In cases of indifference, I shall always presume that producers adopt the allocation intended for them.

The final constraint is that the allocation mechanism provide consumers some reservation utility,  $U^*$ . In what follows, I also presume that US consumers are the only source of income to finance the payments to producers, and, thus, this last constraint can be written:

$$U(q_1 + q_2) - B_1 - B_2 \geq U^*. \quad (4)$$

This treatment of the consumers may appear to differ from other agricultural policy models where finances to run agricultural programs are raised from an amorphous group of 'taxpayers', who are usually treated as if they were distinct from consumers. But, really, the difference is only apparent because here  $U(q_1 + q_2)$  represents the US evaluation of the agricultural commodity as a consumption item and encompasses the benefits to US society as a whole of consuming the amount  $q_1 + q_2$ , while  $B_1 + B_2$  represent societal expenses. Notice that the implicit assumption behind the additive aggregation of consumers and taxpayers used in traditional farm policy analyses (e.g. Gardner; Alston and Hurd) is the existence of such a representative utility function that depends only on the quantity consumed.

The constrained Paretian policy chooses  $(B_i, q_i)$   $i = 1, 2$  to:

$$\text{Max } \{B_1 - q_1: (1) - (4)\} = V^C(U^*).$$

The next section presents some basic results that this allocation mechanism must satisfy.

### Some Preliminary Results

It is useful to start with a definition. In what follows, I refer to the *first best* (from the US perspective) as the mechanism that would emerge if the United States were free to ignore its 'national-treatment' obligation. Denoting  $V(U^*)$  as the level of net returns to US farmers, the formal definition of the first best is given by:

$$V(U^*) = \text{Max } \{B_1 - q_1: (1) \text{ and } (4)\}$$

$V(U^*)$  solves the optimal nonlinear pricing and nonlinear tariff problem for the United States. Its purpose here is not to illustrate existing US agricultural policy but to provide a point of reference for the constrained Paretian policy; the first best describes optimally designed (from the US perspective) agricultural policies that are not subject to the national-treatment constraints. The first-best production pattern is the same as that achieved in the free-market mechanism, but

the distribution of rents differs: All rents over and above the consumer's reservation utility go to US producers. This fact, however, allows direct comparison of our results on production patterns for  $V^c(U^*)$  with free-market production outcomes. By definition, it follows easily that:

$$V(U^*) \geq V^c(U^*).$$

Any positive difference between returns to US producers in the first best and the constrained Paretian mechanism emerges from the 'national-treatment' constraints. A simple mechanism to achieve the first best outcome is linear pricing with lump-sum taxation of importers.

Our first preliminary result shows that it is never optimal to leave the Mexican rationality constraint, (1), slack in the first best or to leave the consumer reservation utility constraint slack in either the constrained Paretian or the first-best mechanisms. (All proofs are in the Appendix.)

**Lemma 1:** For either the constrained Paretian mechanism or the first-best mechanism, constraint (4) must hold with equality. For the first-best mechanism, constraint (1) holds with equality.

Perhaps the most important thing about Lemma 1 is that one can show that Mexican producers are always pushed to their reservation profit (zero) in the first best, but one cannot prove that a policy involving 'national treatment' of traded goods will push Mexican producers to their reservation profit. Thus, while US producers can capture all available surplus (over and above  $U^*$ ) in the first-best agricultural policy, they will not capture all available surplus under national treatment. This may happen in some instances, but, more generally, one expects Mexican producers to realize a positive gain from participating in the mechanism when 'national-treatment' is in effect.

Next we establish orderings imposed upon the allocations by the 'national-treatment' requirement and our differing cost assumptions:

**Lemma 2:** Under Assumption 1, any constrained Paretian allocation mechanism must satisfy

$$q_1 \geq q_2.$$

**Lemma 3:** Under Assumption 2, any constrained Paretian allocation mechanism must satisfy

$$q_2 \geq q_1.$$

Lemmas 2 and 3 show that the constrained Paretian allocation mechanism can never involve the high-cost country producing the majority of the output. The economic importance of these lemmas is emphasized by considering what this implies under Assumption 2, where the United States is the high-cost country. (Actual agricultural examples might include certain fruits and vegetables and some floricultural products.) Suppose under these circumstances that the United States tried to implement a mechanism that reserved all of the market for US producers. This policy would imply a degenerate market, i.e., one that disappears, because it would require via Lemma 3 that  $0 \geq q_1$ .

Lemmas 2 and 3 only represent necessary conditions for a constrained Paretian allocation mechanism to be feasible. Several things should be noted: First, the first-best production allocation always satisfies Lemmas 2 and 3. Allocations can satisfy Lemmas 2 and 3 and still not be consistent with the national-treatment requirements. Finally, an agricultural policy can satisfy national treatment and still involve quantity-based price discrimination so long as it is anonymous. Some might argue, however, that even anonymous price discrimination violates national treatment. If so, the only alternative to the policies described below are "decoupled" policies.<sup>1</sup>

Our final preliminary result shows that both national-treatment constraints can bind under only very special circumstances.

**Lemma 4:** Both of the national-treatment constraints ((2) and (3)) are binding under either Assumption 1 or Assumption 2 if and only if Mexico and the United States split the market, i.e.,  $q_1 = q_2$ , and  $B_1 = B_2$ .

### Solving the Constrained Paretian Problem

Unlike Chambers, who uses Lagrangian methods which are only approximate, this paper provides exact solutions to the mechanism-design problem. The first step in characterizing that solution is to recognize, following Grossman and Hart and Weymark, that the constrained Paretian problem can be decomposed into a two-stage optimization problem. This recognition ultimately allows one to develop a simple graphical treatment of the current problem. And, although it is not pursued here, these tools can be used to analyze other mechanism-design problems with similar structures.

In the first stage, the payment schedule  $(B_1, B_2)$  is chosen to maximize US producer surplus for a given production vector  $(q_1, q_2)$ , and in the second stage the optimal production vector is chosen. Thus, the first-stage problem is to pick  $(B_1, B_2)$  for fixed  $(q_1, q_2)$  to solve:

$$\text{Max } \{B_1 - C_1(q_1): (1) - (4)\}.$$

The first-best version of the first-stage problem is defined analogously, i.e., choose  $B_1$  and  $B_2$ :

$$v(q_1, q_2, U^*) = \text{Max } \{B_1 - C_1(q_1): (1) \text{ and } (4)\}.$$

If the feasible set for the first-best, first-stage problem is nonempty, its solution is easily computed after using Lemma 1<sup>2</sup>:

$$B_2 = C_2(q_2),$$

and

$$B_1 = U(q_1 + q_2) - C_2(q_2) - U^*,$$

whence,

$$v(q_1, q_2, U^*) = U(q_1 + q_2) - C_2(q_2) - C_1(q_1) - U^*.$$

The optimal value of the first-best, first-stage problem equals net social surplus from the production of  $q_1$  and  $q_2$ . As expected, therefore, the optimal solution to the overall first-stage problem just entails maximizing net social surplus captured by US producers.

The first-stage, constrained Paretian problem is a linear program because for given  $(q_1, q_2)$  the constraints and the objective function are linear in  $B_1$  and  $B_2$ . Hence, its solutions can be easily characterized using graphical analysis. Consider the consumer-valuation constraint, (4): Lemma 1 implies that  $(B_1, B_2)$  should be chosen so that US consumers just achieve their reservation utility. Graphically, this means that any solution to the first-stage, constrained Paretian problem must lie somewhere on the line segment defining (4) in  $(B_1, B_2)$  space. Figure 1 illustrates (4) by the line segment with a slope of minus 1. (As drawn, I have restricted attention to the positive orthant. For given  $(q_1, q_2)$ , a negative  $B_1$  may be consistent with some of the other constraints, but since it implies that the United States knowingly designs a scheme where US producer returns are negative I ignore it in what follows.)

Now consider the national-treatment constraints, (2) and (3). Slightly rewriting (2) yields:

$$B_1 \geq B_2 + C_1(q_1) - C_1(q_2).$$

The set of  $(B_1, B_2)$  pairs obeying this constraint is given by the set of points lying above a ray parallel to the bisector, i.e., having slope of one with a vertical intercept of  $C_1(q_1) - C_1(q_2)$ .

Performing a similar operation for constraint (3):

$$B_2 + C_2(q_1) - C_2(q_2) \geq B_1.$$

The set of  $(B_1, B_2)$  pairs obeying this constraint are given by all points lying below a ray parallel to the bisector, i.e., having slope of one with a vertical intercept of  $C_2(q_1) - C_2(q_2)$ . Graphically,

it is easy to see that the intersection of these two sets is empty unless the intercept of the ray associated with (3) is higher than that for (2), i.e.:

$$C_2(q_1) - C_2(q_2) \geq C_1(q_1) - C_1(q_2), \quad (5)$$

and the intersection is the bisector if (5) holds as an equality. So unless  $(q_1, q_2)$  satisfy (5), the feasible set for the first-stage, constrained Paretian problem is empty. This leads us to the following definition:

**Definition:** Denote by  $v^c(q_1, q_2; U^*)$  the maximum net return to US producers given  $(q_1, q_2)$  and (1) - (4). If the set of  $(B_1, B_2)$  satisfying (1) - (4) given  $(q_1, q_2)$  is empty:

$$v^c(q_1, q_2; U^*) = -\infty.$$

If the set of  $(B_1, B_2)$  satisfying (1) - (4) given  $(q_1, q_2)$  is nonempty:

$$v^c(q_1, q_2; U^*) = \text{Max } \{B_1 - C_1(q_1): (1) - (4)\}.$$

Expression (5) motivates the following alternative manifestations of Lemmas 2 and 3:

**Lemma 2a:** Under Assumption 1,  $v^c(q_1, q_2; U^*) \neq -\infty$  only if:

$$q_1 \geq q_2.$$

**Lemma 3a:** Under Assumption 2,  $v^c(q_1, q_2; U^*) \neq -\infty$  only if:

$$q_2 \geq q_1.$$

Lemmas 2a and 3a just reiterate the earlier finding that no solution satisfying 'national treatment' ever involves the high-cost producer producing more than the low-cost producer. Therefore, in what follows when we consider the first-stage problem under Assumption 1 we shall always restrict our attention to these  $q$  vectors satisfying  $q_1 \geq q_2$ . Similarly, when Assumption 2 applies, we restrict our attention to  $q_2 \geq q_1$ . Other production patterns will not be feasible candidates for the second-stage problem.

Figure 2 illustrates the situation where the intersection of the sets defined by (5) is not empty under Assumption 1, i.e., the United States is the low-cost country. By (5) and because  $q_1 \geq q_2$ , the intercept of the ray defining constraint (2) is positive and lower than the intercept of the ray defining constraint (3). The set of points between the two rays is what I shall refer to as the *national-treatment cylinder* and comprises all  $(B_1, B_2)$  combinations consistent for given  $(q_1, q_2)$  with US producers voluntarily adopting the allocation intended for them, and Mexican producers voluntarily adopting the allocation intended for them.<sup>3</sup>

The feasible  $(B_1, B_2)$  pairs are a subset (perhaps the empty set) of the intersection of the consumer valuation constraint, (4), and the national-treatment cylinder. This latter intersection of sets is illustrated pictorially in Figure 2 by the line segment connecting points A and B. Geometrically, the final constraint, the Mexican producers' rationality constraint, (1), is represented by a line segment parallel to the vertical axis which intersects the horizontal axis at  $C_2(q_2)$ . Everything to the right of that line segment satisfies (1).

Several possibilities exist. First, if the Mexican producer constraint intersects the consumer valuation constraint to the right of B, the feasible set is the empty set, and  $v^c(q_1, q_2; U^*) = -\infty$ . Second, if the vertical line segment intersects the consumer valuation constraint to the left of point A, i.e.,  $C_2(q_2) < B_2^*$ , the feasible set is the line segment AB. In this case, the solution to the constrained Paretian problem is given by point A in Figure 2, whence

$$v^c(q_1, q_2; U^*) = B_1^* - C_1(q_1),$$

and

$$B_2^* > C_2(q_2).$$

This follows because the preference direction for the constrained Paretian problem is due north implying that the optimal  $B_1$  is the highest one consistent with all the constraints,  $B_1^*$ . Notice,



in particular, that in this instance the Mexican producers' rationality constraint is not binding, and that they, in fact, receive a strictly positive return from their sale of  $q_2$ .

This solution is usefully compared with the first best where  $B_2 = C_2(q_2)$ . The national treatment restriction does two things: it guarantees Mexican producers a profit that they would not have realized otherwise; and it curtails US producer returns just enough from the first best to make it unattractive for Mexican producers to adopt the US allocation. The difference between their first-best profit and  $B_1^* - C_1(q_1)$  is the cost to US producers of the allocation mechanism meeting the national-treatment criterion. In these circumstances, US producers lose from the implementation of the national-treatment constraints, while Mexican producers gain as compared to the first best.

The final possibility illustrated (apart from the obvious ties, of course) is where the Mexican producers' rationality constraint is binding. Pictorially, this is illustrated in Figure 3 by having the vertical line segment intersect the consumer-valuation constraint between points A and B. In that instance, producers are both given their first-best payments and the national-treatment restriction has no effect on the agricultural policy actually developed.

Several interesting points emerge: The first is another set of necessary conditions beyond those provided by (5) and Lemmas 2a and 3a for the feasible set of the constrained Paretian problem to be nonempty:

**Result 1:** Under Assumption 1 for  $q_1 \geq q_2$ ,  $v^c(q_1, q_2; U^*) \neq -\infty$  only if

$$U(q_1 + q_2) - C_1(q_1) - C_2(q_2) \geq U^*.$$

Under Assumption 2 for  $q_2 \geq q_1$ ,  $v^c(q_1, q_2; U^*) \neq -\infty$  only if

$$U(q_1 + q_2) - C_1(q_1) - C_2(q_2) \geq U^* + C_2(q_2) - C_1(q_2).$$

When the United States is the low-cost producer, a feasible solution only exists if net surplus from production and sale of the agricultural commodity ( $U(q_1 + q_2) - C_1(q_1) - C_2(q_2)$ ) exceeds US consumers reservation utility.

From Figures 1 through 3, it is visually apparent that, except in unusual circumstances (and ruling out the trivial case where  $q_1 = q_2$  and both constraints must bind by Lemma 4), constraint (2) is not binding in the solution to the first-stage, constrained Paretian problem. This implies, in turn, that constraint (2) generally will not bind in the *optimum optimorum* of the constrained Paretian problem. More formally:

**Result 2:** Under Assumption 1 for  $q_1 > q_2$ , constraint (2) binds in a solution to the first-stage, constrained Paretian problem only if constraint (1) also binds, and

$$B_1 - C_1(q_1) = C_2(q_2) - C_1(q_2) > 0.$$

The economic interpretation of Result 2 is that US producers will only be just indifferent to the Mexican allocation when Mexican producers are just indifferent between participating in the allocation mechanism and not participating and US producers reap a profit just equalling their cost advantage in producing  $q_2$ . (Mexican producers adopting  $(B_1, q_1)$ , thus, would just break even.) Graphically, this is the case where the Mexican rationality constraint intersects the national-treatment cylinder at B.

Constraint (2) does not generally bind because it reflects mathematically the requirement that US producers weakly prefer the US allocation. However, the national agricultural policy goal is to find allocations which transfer as much surplus as possible to US producers subject to consumer rationality, Mexican producer rationality, and the national-treatment constraints. Therefore, one expects incentive problems to run in the other direction, i.e., preventing Mexican producers from adopting the presumably more favorable US allocation. Hence, only in the most

extreme circumstances, such as those illustrated where the only feasible solution is given by point B in Figure 2, will constraint (2) ever be binding.<sup>4</sup>

It is now follows easily that:

**Corollary 2.1:** Under Assumption 2 for  $q_2 > q_1$ , if a feasible solution exists then constraint (2) is binding only if constraint (1) is also binding and

$$B_1 - C_1(q_1) = C_2(q_2) - C_1(q_2) < 0.$$

Corollary 2.1 effectively removes the possibility that constraint (2) will ever bind when the United States is the high-cost producer because it demonstrates that if constraint (2) is binding the best that can be done for US producers in the face of national treatment is to leave them with a negative profit. US producers would be better off if they just conceded the entire market to Mexican producers.

We can now characterize the solution to the first-stage, constrained Paretian problem:

**Result 3:** If the feasible set is nonempty, any solution to the first-stage, constrained Paretian problem is characterized by either:

$$U(q_1 + q_2) - B_1 - B_2 = U^*,$$

$$B_2 - C_2(q_2) = B_1 - C_2(q_1);$$

or

$$U(q_1 + q_2) - B_1 - B_2 = U^*,$$

$$B_2 - C_2(q_2) = 0.$$

The following corollary, giving the optimal values of the first-stage objective function, is an immediate consequence:

**Corollary 3.1:** If the feasible set is nonempty,  $v^c(q_1, q_2; U^*)$  is given by either of the following twice differentiable functions:

$$U(q_1 + q_2) - C_2(q_2) - C_1(q_1) - U^* = v(q_1, q_2; U^*);$$

or

$$(U(q_1 + q_2) - C_2(q_2) + C_2(q_1) - U^*)/2 - C_1(q_1).$$

Our final result in this section gives a necessary condition for the solution to the first-stage, constrained Paretian solution to correspond to the first-stage, first-best problem:

**Result 4:** If the feasible set is nonempty,  $v^c(q_1, q_2; U^*) = v(q_1, q_2; U^*)$  only if:

$$C_2(q_1) \geq U(q_1 + q_2) - U^* - C_2(q_2).$$

Result 4 is easy to interpret because the inequality there demarcates the region where Mexican producers will make either a zero or a negative profit if they adopt the US allocation  $(B_1, q_1)$  when  $B_1$  and  $B_2$  are chosen at their first-best levels (conditioned on given  $q_1$  and  $q_2$ ). If this conditions fail to hold and  $B_1$  and  $B_2$  are set at their first-best levels (for given  $q_1$  and  $q_2$ ), Mexican producers will always make a positive profit by adopting  $(B_1, q_1)$ : The first-stage, first best is not implementable.

### An Optimal Agricultural Policy Under National Treatment

We are now ready to characterize the optimal agricultural policy under national treatment.

By Result 3, the optimal agricultural policy chooses  $(q_1, q_2)$  to solve:

$$\begin{aligned} &\text{Max } \{v^c(q_1, q_2; U^*)\} \\ &q_1, q_2 \end{aligned}$$

subject to (5). When  $v^c(q_1, q_2; U^*) = v(q_1, q_2; U^*)$ , this corresponds to the first best, which is well known and will not be examined in any great detail. Result 4 has an another immediate Corollary which establishes parametrically when the first best cannot be implemented:

**Corollary 4.1:** The first-best agricultural policy defined by  $(\hat{q}_1, \hat{q}_2)$  satisfying

$$U'(\hat{q}_1 + \hat{q}_2) = C'_2(\hat{q}_2) = C'_1(\hat{q}_1),$$

with  $\hat{B}_2 = C_2(\hat{q}_2)$ , and  $\hat{B}_1 = U(\hat{q}_1 + \hat{q}_2) - C_2(\hat{q}_2) - U^*$  cannot be implemented if

$$(NFB) \quad C_2(\hat{q}_1) < U(\hat{q}_1 + \hat{q}_2) - U^* - C_2(\hat{q}_2).$$

If NFB is satisfied, then the constrained Paretian allocation cannot be the first-best allocation. Under NFB, Mexican farmers make a positive profit if they adopt  $(\hat{B}_1, \hat{q}_1)$ . And because  $\hat{B}_2 = C_2(\hat{q}_2)$ , they would thus supply  $\hat{q}_1$  instead of  $\hat{q}_2$ . Hence, the first best would not be implementable. An obvious, but important, point is that US producers would prefer that NFB not hold for in that circumstance the first best could be implemented and with it the higher returns to US producers.

I shall investigate the constrained Paretian allocation under both Assumptions 1 and 2. Under Assumption 1, restriction (5) can be replaced by the single linear inequality  $q_1 \geq q_2$  in specifying the constrained maximization problem, because so long as  $q_1 \geq q_2$  (5) is satisfied. (This is the gist of Lemma 2.) Moreover, this latter constraint can be removed from the optimization problem by defining  $\alpha \geq 0$  by

$$q_1 = q_2 + \alpha.$$

and substituting this expression into  $v^c(q_1, q_2; U^*)$ . The constrained optimization problem then reduces to a simple, nonlinear program where  $q_2$  and  $\alpha$  are chosen subject only to nonnegativity constraints. Making this substitution the problem becomes under Assumption 1:

$$\text{Max}_{q_2, \alpha} \{(U(q_2 + \alpha + q_2) - C_2(q_2) + C_2(q_2 + \alpha) - U^*)/2 - C_1(q_2 + \alpha)\}.$$

Thus, it follows immediately from the first-order conditions that for an interior solution for  $\alpha$  (i.e., the market is not split in the sense of Lemma 4):

**Result 5:** If  $q_1 > q_2 > 0$ , the optimal agricultural policy under Assumption 1 and NFB satisfies:

$$U'(q_1 + q_2) - C'_2(q_2) = 0,$$

and

$$[C'_2(q_2) + C'_2(q_1)]/2 - C'_1(q_1) = 0 .$$

The structure of the optimal agricultural policy in Result 5 is usefully compared with the first best. In the first best,  $\hat{q}_1$  and  $\hat{q}_2$  are chosen to equate marginal cost of production to US marginal willingness to pay for the commodity. Here, only the marginal cost of Mexican producers equals US marginal willingness to pay. The marginal cost of US producers here equals the average of the Mexican marginal cost of producing  $q_2$  and the Mexican marginal cost of producing  $q_1$ . By Lemma 2a and cost convexity  $C'_2(q_1) > C'_2(q_2)$  so that

$$\frac{C'_2(q_1) + C'_2(q_2)}{2} > C'_2(q_2).$$

It follows immediately from the result that  $C'_1(q_1) > U'(q_1 + q_2)$ . In a sense (which I make more precise below), therefore, US production is excessive: At the margin US consumers would not be willing to pay for a further unit increment in US production of output if they had to match the associated marginal cost. In fact, US production of the commodity is higher than in the first best while Mexican production of the commodity is less than in the first best.

To understand this last claim, consider Figure 4 where I have depicted the first-best production equilibrium graphically. As noted above, the first best solves:

$$U'(\hat{q}_1 + \hat{q}_2) = C'_1(\hat{q}_1), \tag{6}$$

$$U'(\hat{q}_1 + \hat{q}_2) = C'_2(\hat{q}_2). \tag{7}$$

The locus of points satisfying (6) is depicted by curve I in the figure, while the locus of points satisfying (7) is depicted by curve II. Some calculus and algebra show that I always cuts II from below. The area above each curve represents those points where marginal cost for the respective producers exceeds marginal willingness to pay, while the points below the curves are where marginal cost is less than marginal willingness to pay.

By Result 5, expression (7) holds in the constrained Paretian equilibrium under Assumption 1. Thus, the constrained Paretian equilibrium must lie somewhere on curve II. But as we have just shown, marginal cost of US producers exceeds consumer marginal willingness to pay. Hence, the constrained Paretian equilibrium must be on II above the first-best equilibrium: US producers produce more than in the first best and Mexican producers produce less.

**Corollary 5.1:** Under the conditions of Result 5:

$$q_1 > \hat{q}_1 > \hat{q}_2 > q_2.$$

The economic effect of introducing the national-treatment requirement is to increase the dispersion of output between the two countries over and above the first-best and free-market production allocations. To see why this happens consider the following: Under Assumption 1, the United States is the low-cost producer. That implies that it can expand output more cheaply than Mexico. Under national-treatment, the policy problem is to divert as much surplus to US producers as possible without attracting Mexican producers to the US allocation. One way is to expand the US output allocation beyond the first-best level. If Mexican producers want to adopt the US allocation, and thus receive the US payment they must meet this output expansion, but doing so costs them more at the margin than US producers. As long as the payment to US producers does not exceed the payment to Mexican producers by more than this increase in cost (i.e.,  $(B_1 - B_2) \leq C_2(q_1) - C_2(q_2)$ ), Mexican producers will not find it advantageous to adopt the US allocation. Hence, expanding the output dispersion from the first best is a way of anonymously diverting surplus to US producers in the face of the national-treatment obligation.

Mexican producers, however, gain from this arrangement (as compared to the first best) because they now make a strictly positive return even though they produce less than in the first

best. This illustrates an important and frequently misunderstood point: producer welfare in a trading context is not necessarily positively correlated with the volume of trade. Here, Mexican producers exercise no monopolistic power in the market and yet they are clearly better off than in the first best even though their export volume has dropped. The reason is that national treatment constrains the range in which the low-cost producer (here the United States) can exercise its ability to discriminate perfectly against Mexican producers.

The final aspect of these results that needs explanation is the fact that Mexican producers choose output to equate marginal cost of production to US consumer marginal willingness to pay. This happens because the incentive problem is structured in such a way that US producers will never be attracted to the Mexican constrained Paretian allocation. Hence, there is no need to induce any production inefficiency on the part of Mexican producers as a mean of encouraging US producers not to adopt the Mexican allocation. In fact, inducing production inefficiency for Mexican producers is always counter-productive because it would only diminish the pool of surplus available to be redistributed to US producers. Suppose, for example, that US consumers willingness to pay exceeded Mexican marginal cost. US consumers should be more than willing to meet the marginal cost increase associated with a Mexican output expansion. The marginal difference between this willingness to pay and Mexican marginal cost could be diverted to US producers.

From this discussion, Result 5, and Corollary 5.1, we can now easily establish precisely what I meant earlier when I claimed that US production was excessive. From Result 5, it follows that for an interior solution:

$$C'_2(q_2) = U'(q_1 + q_2),$$



whereas Corollary 5.1 establishes that  $q_2 < \hat{q}_2$ . Together with the convexity of costs, these two facts establish that:

$$U'(q_1 + q_2) < U'(\hat{q}_1 + \hat{q}_2),$$

which with the strict concavity of  $U$  implies:

$$q_1 + q_2 > \hat{q}_1 + \hat{q}_2.$$

**Corollary 5.2:** Under the conditions of Result 5, the increase in US output from the first best exceeds the decline in Mexican output from the first best.

Thus, total production and sales of the agricultural commodity in the constrained Paretian mechanism must exceed total sales and production of the agricultural commodity in the first best and the completely free market. When the United States is the low-cost producer, national treatment acts to expand the market size.

Under Assumption 2, the first-order conditions are identical to those derived under Assumption 1. We have for an interior solution for  $\alpha$ :

**Result 6:** If  $q_2 > q_1 > 0$ , the optimal agricultural policy under Assumption 2 and NFB satisfies:

$$U'(q_1 + q_2) - C'_2(q_2) = 0,$$

and

$$[C'_2(q_2) + C'_2(q_1)]/2 - C'_1(q_1) = 0.$$

So under Assumption 2, one might naturally expect that production would be organized as in Corollary 5.1. However, notice that Assumption 2, Lemma 3, and the convexity of costs imply  $C'_2(q_1) < C'_2(q_2)$  in Result 6. Thus, while Mexican producers still produce an output that equates marginal cost of production to US marginal willingness to pay, US producers now produce an output for which marginal cost of production is less than US marginal willingness to pay. An entirely analogous argument to that used to establish Corollary 5.1 now yields:

**Corollary 6.1:** Under the conditions of Result 6:

$$q_2 > \hat{q}_2 > \hat{q}_1 > q_1.$$

So again the dispersion of output expands beyond what it was in the first best when US producers were the high-cost producers. Intuitively, it is easy to see why this happens. As US producers reduce their output, they save their marginal costs. Mexican producers, because they are now the low-cost producers, would save less at the margin by matching this output reduction. Hence, the difference in the marginal cost saving creates an earnings wedge which can be diverted to the now high-cost US producers. Just as before, spreading the production pattern generates an economic incentive for Mexican producers to adopt  $(B_2, q_2)$ .

Using previous arguments, it also follows easily that:

**Corollary 6.2:** Under the conditions of Result 6, the decrease in US output from the first best exceeds the increase in Mexican output from the first best.

So, when US producers are the high-cost producers the optimal national agricultural policy involves shrinking the size of the agricultural market as compared to the first best and the free market.

### **A Potential Mechanism and Limitations**

The results of the previous section have been developed for a highly stylized model. And although the model is certainly no more stylized than many traditional agricultural-policy models, caution should be exercised in suggesting actual policy mechanisms based on results derived from a model with so many unrealistic assumptions. Therefore, the discussion in this section is not intended to be prescriptive. Rather, it is intended to do two things: To describe how some of the outcomes described above might be achieved using a policy implement with which most

readers would be familiar; and in the context of that policy implement to discuss some of the more obvious shortcomings of the model.

An obvious policy implement is the institution of a marketing board bound by the national-treatment constraints, i.e., a marketing board prohibited by law from overtly discriminating against a product on the basis of national origin. Marketing boards have been used in a variety of countries to market a variety of commodities (wheat in Canada, cocoa in Ghana, etc.). And traditionally it has been presumed (Bieri and Schmitz) that a primary goal of the marketing board is the enhancement of domestic producer income at the expense of foreign producers but not at the expense of domestic consumers. The role of the marketing board here would be similar but more limited, because it would be confined by the national-treatment requirement: It would act as the initial buyer of all that is produced and would pay producers on the basis of the quantity that they provided to the board regardless of national origin. However, pricing would be nonlinear; producers who provided  $q_1$  would be paid  $(U(q_1 + q_2) - C_2(q_2) + C_2(q_1) - U^*)/2$ , while producers who sold  $q_2$  would be paid  $(U(q_1 + q_2) + C_2(q_2) - C_2(q_1) - U^*)/2$ .

An obvious problem, which has so far been relegated to the background of our assumptions, is now apparent. And that is what to do about potential trading of the commodity between Mexican and US producers prior to sale of the commodity to the marketing board, side commitments between the same, and about direct trading between producers and consumers outside of the government designed mechanism. For simplicity, I shall refer to all of these as 'retrading'. The implicit assumption all along has been that retrading is prohibited. Realistically, it will be impossible to prohibit retrading of the commodity. So the policy described above cannot be expected to achieve the exact outcome described by the theoretical model. But that

is only to be expected because theory can never accurately portray exactly what happens in the real world. In traditional agricultural policy models, for example, the standard modelling of nonrecourse loan rates only captures their price-support functions and not their interest subsidy functions. However, one way to mitigate the retrading issue is for the marketing board to require legally that it be the first buyer of all of the commodity marketed and the only seller of the commodity for consumption purposes, and then to assume that the marketing board has the authority to enforce this prohibition. And, in fact, there are many instances where a government does act as the first buyer and sole legal seller of a commodity to its populace: At a national level, Sweden controls marketing of alcoholic beverages through state-run stores; while, in the United States, many municipal and state-level jurisdictions control marketing of alcoholic beverages through "package" stores.

## **Conclusion**

This paper has studied the formulation of an optimal national agricultural policy in the context of a free-trade area. Using the principles of mechanism design the optimal agricultural policy has been characterized. It has been shown that a national agricultural policy designed in the presence of national-treatment requirements always has the lower-cost producer producing the most output and will have a greater dispersion in output between the partners to the free-trade area than an optimal national policy designed in the absence of national-treatment requirements. When the country designing the mechanism is the low-cost producer it expands the market as compared to what would occur in the first best or under free trade; when it is the high-cost producer it shrinks the market. The paper has also developed a simple graphical apparatus for analyzing mechanism design that can be applied usefully to similar problems.

Several extensions of the research reported above are obvious. For example, because the mechanism-design problem has been reduced to a simple nonlinear program, comparative-static analysis of the optimal outcomes is straightforward. Some such results are so immediate as to be trivial: for example,  $\bar{U}^* \geq U^*$  implies  $V^c(\bar{U}^*) \leq V^c(U^*)$ . Because  $U^*$  represents consumer and taxpayer welfare in the present model, this latter result implies that the slope of the 'surplus-transformation curve' between US producers and consumers is negative. Others are less trivial but still easy. To illustrate suppose that  $C_2(q)$  could be rewritten as  $H(t) \hat{C}_2(q)$  where  $t$  is an index of the technology and  $H(t)$  captures the possibility of technical change. Technical change would then be cost reducing if  $H'(t) < 0$ . It follows immediately from the above that cost reducing technical change in Mexico reduces  $V^c(U^*)$  if the United States is the low-cost country and increases  $V^c(U^*)$  if the United States is the high-cost country.

Another obvious extension of the above is to recognize that NAFTA actually has three partners — United States, Mexico, and Canada. Introducing a third country into the analysis is easy: It just means that additional national-treatment and rationality restrictions must be introduced. The two-step decomposition of the problem remain intact. And the first stage is still a linear program. However, the graphical simplicity of the model would be lost.

### Endnotes

1. Again, the reader is reminded that all traditional policy implements including explicit and implicit import subsidies can be represented as mechanisms.
2. Strictly speaking Lemma 1 should be rederived for the first-best, first stage problem. However, it is easy to see that it continues to apply.
3. I have not illustrated what happens under Assumption 2. The picture remains basically the same except that the intercepts of both rays defining the outer edges of the national-treatment cylinder are negative, i.e., the national-treatment cylinder lies below the bisector.
4. Of course, if the policy were:

$$\text{Max } \{B_2 - C_2(q_2): (1) - (4)\},$$

constraint (2) would generally bind while constraint (3) would be slack.

## Appendix

**Proof of Lemma 1:** For the first best if constraint (4) is slack, it is possible to raise  $B_1$  by a strictly positive amount thus increasing the objective function without violating constraint (1). For the constrained Paretian mechanism if constraint (4) is slack it is possible to raise both  $B_1$  and  $B_2$  by the same small positive amount thus improving the objective function while preserving constraints (1) - (4). For the first best if constraint (1) is slack, it is possible to raise  $B_1$  by a small positive amount and reduce  $B_2$  by the same amount thus not changing (4) but increasing  $V(U^*)$ . Hence, constraint (1) could not be slack in the optimum.

**Proof of Lemma 2 and Lemma 3:** Only Lemma 2 is proved, the proof of Lemma 3 is a straightforward extension and is left to the reader. Add the 'national-treatment' constraints together to get:

$$C_1(q_2) - C_1(q_1) \geq C_2(q_2) - C_2(q_1).$$

Under Assumption 1, marginal cost for US producers is always less than marginal cost for Mexican producers. Therefore, this last equality can only hold if  $q_1 \geq q_2$ .

**Proof of Lemma 4:** Sufficiency is obvious. To prove necessity, suppose both constraints are binding and add them together to get:

$$C_1(q_2) - C_1(q_1) = C_2(q_2) - C_2(q_1).$$

Under either Assumption 1 or Assumption 2, either the United States or Mexico will enjoy a strict cost advantage in producing any given output. Thus, the above equality can hold only if  $q_1 = q_2$ . This establishes that the market must be split. Now suppose that the market is split. Then the national treatment constraints reduce to

$$B_1 \geq B_2, \text{ and}$$

$$B_2 \geq B_1.$$

This establishes the second part of the result.

**Proof of Result 1:** Add the consumer valuation constraint (4) and constraint (2) to obtain:

$$U(q_1 + q_2) - B_2 - C_1(q_1) \geq U^* + B_2 - C_1(q_2).$$

Multiply the Mexican producers' rationality constraint by 2 and add it to the above to get:

$$U(q_1 + q_2) - C_1(q_1) - C_2(q_2) \geq U^* + C_2(q_2) - C_1(q_2).$$

Assumption 1 implies that  $C_2(q_2) - C_1(q_2) \geq 0$ , proving the Result.

**Proof of Result 2:** First use Lemma 4 to establish that if (2) binds exactly then (3) must be slack implying:

$$B_2 - C_2(q_2) > B_1 - C_2(q_1).$$

Now suppose that constraint (1) does not bind contradicting the Result, then:

$$B_2 - C_2(q_2) > 0.$$

A small increase in  $B_1$  and a small decrease in  $B_2$  by the same amount will preserve constraint (4), turn constraint (2) into a slack constraint, while still maintaining the inequalities above and improving the objective function. Because it is possible to find a feasible improvement in the objective function it could not have been optimal to have constraint (2) bind if constraint (1) did not.

**Proof of Result 3:** By Result 2, constraint (2) only binds if constraint (1) also binds. Hence, any solution is characterized completely by constraints (1), (3), and (4). Constraint (4) always binds by Lemma 1. The result is proved by showing that any the solution to the problem cannot involve  $B_2 - C_2(q_2) > B_1 - C_2(q_1)$  and  $B_2 - C_2(q_2) > 0$  (i.e., both (1) and (3) slack). Suppose it did, then one can drop  $B_2$  by an arbitrarily small but positive amount and raise  $B_1$  by the same arbitrarily small but positive amount thus increasing the value of the objective function while preserving constraints (1) - (4). Thus, the original allocation could not have been optimal.

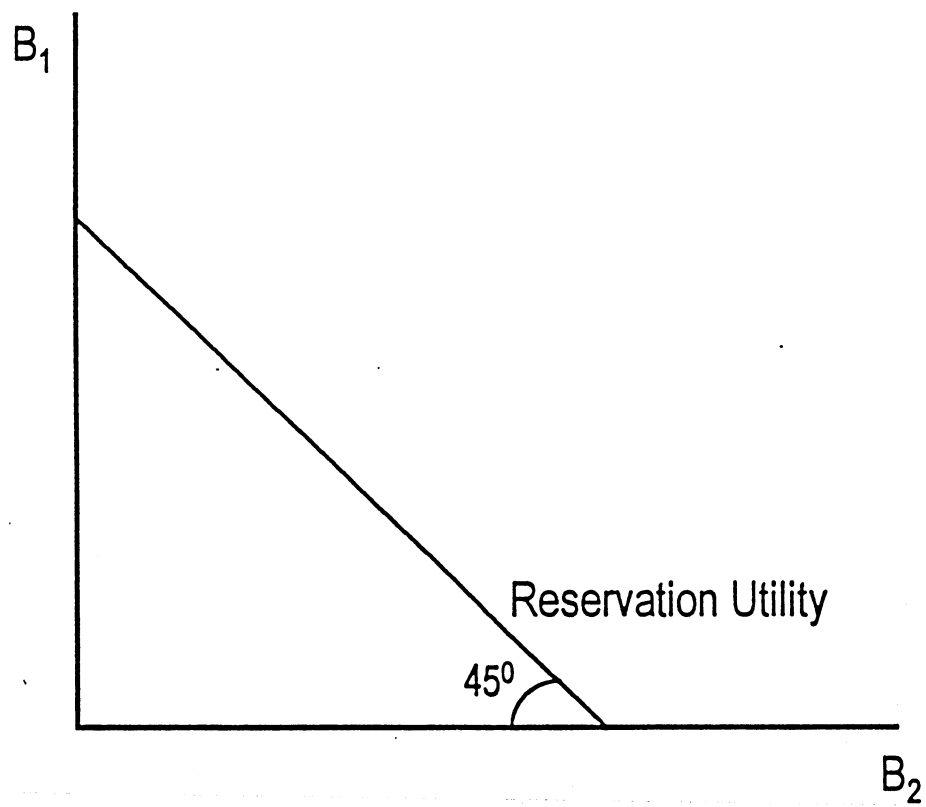


**Proof of Result 4:** To establish necessity suppose that  $C_2(q_2) = B_2$  and  $B_2 - C_2(q_2) \geq B_1 - C_2(q_1)$ .

Using Result 3 to solve for  $B_1$  gives  $U(q_1 + q_2) - U^* - C_2(q_2)$  and substituting this into the above inequality gives  $0 \geq U(q_1 + q_2) - U^* - C_2(q_2) - C_2(q_1)$ .

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**Figure 1: Reservation Utility Constraint**

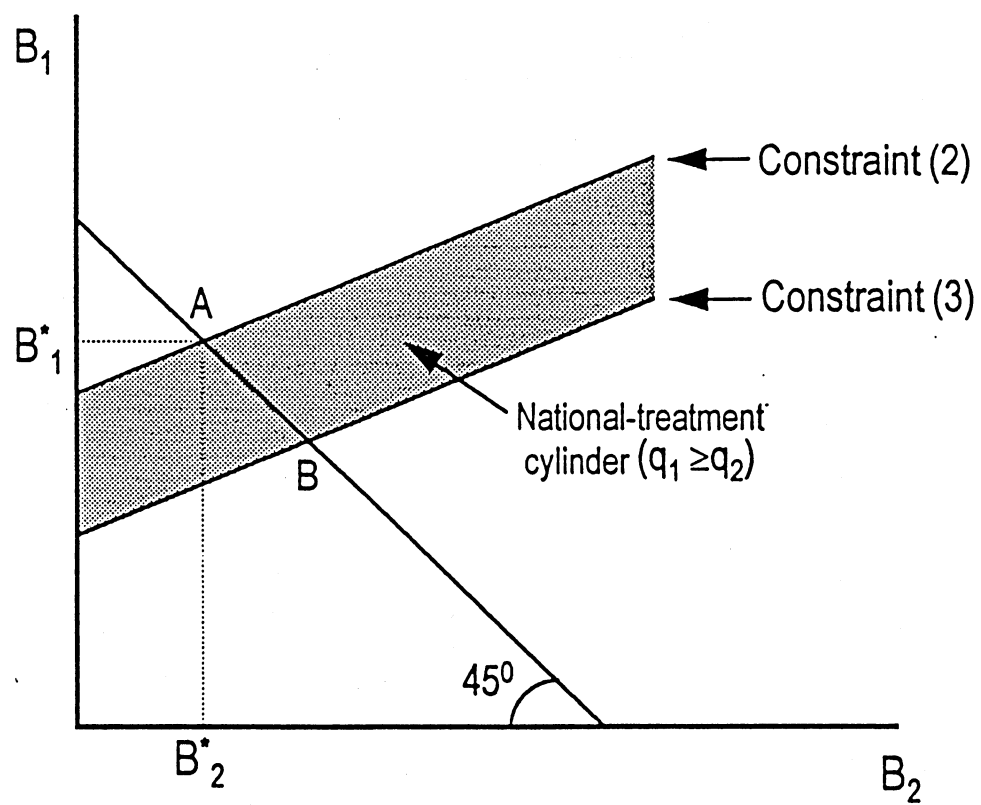
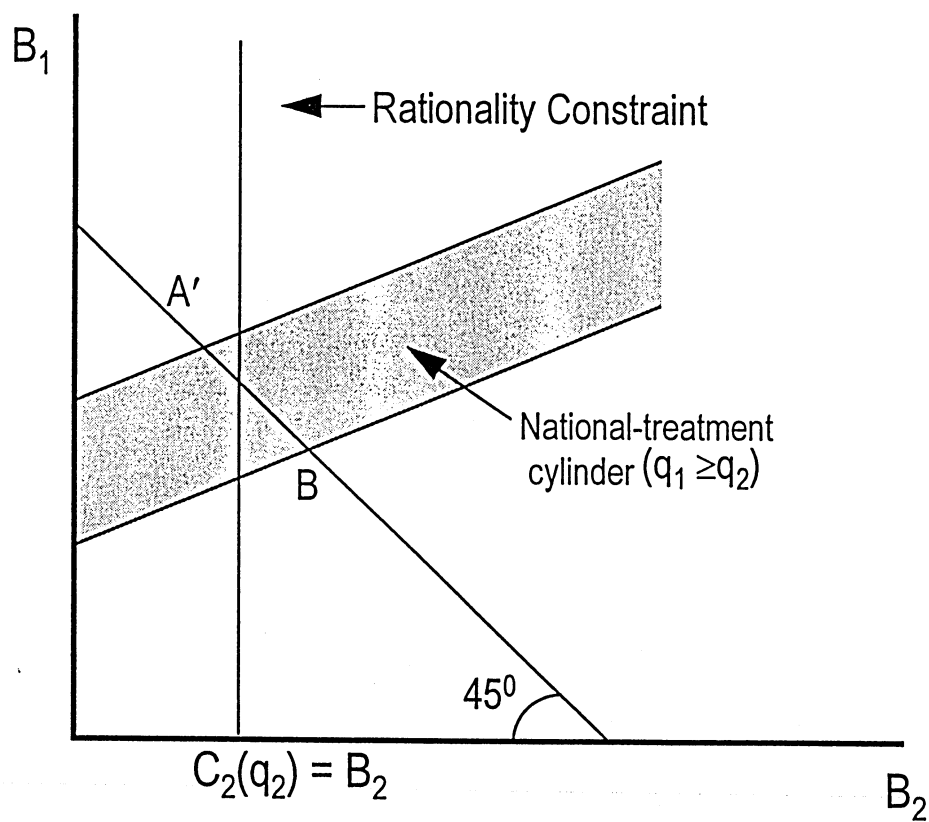


Figure 2: The National-Treatment Cylinder



**Figure 3: First Best**

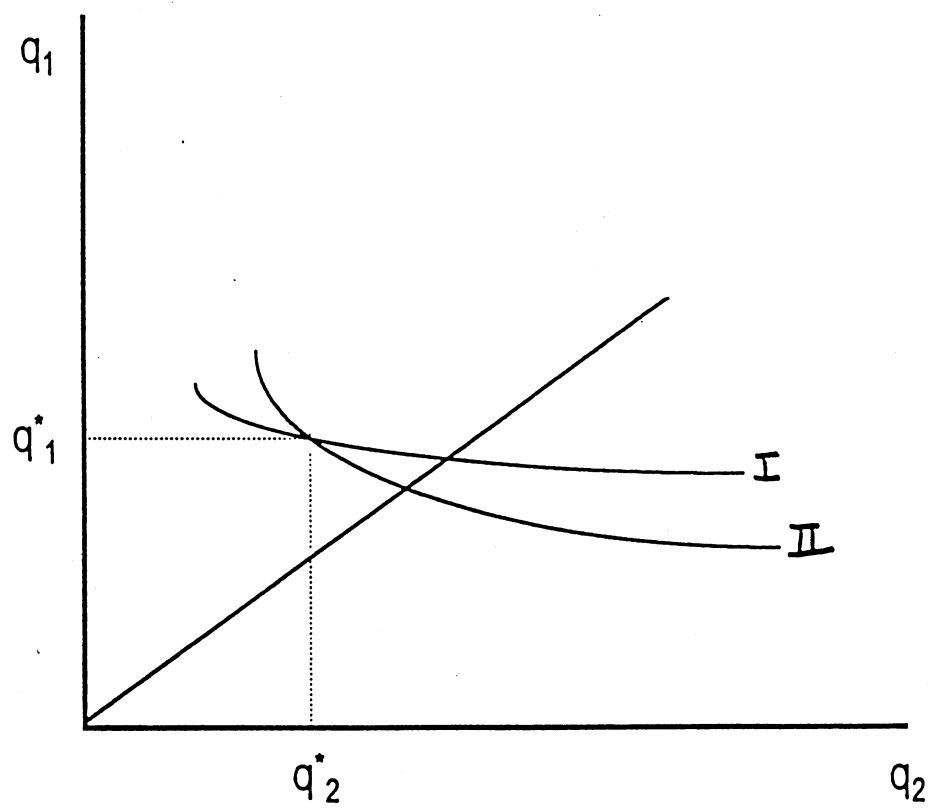


Figure 4: The First-Best Solution