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Targeted Agricultural Export Subsidies and Social Welfare*

by

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ABSTRACT

Most agricultural export subsidies are targeted to specific countries. This paper demonstrates that in a standard general equilibrium model of international trade, a small targeted subsidy increase the welfare of the subsidizing country by exploiting differences in price responsiveness of demand relationships of importers. A single-product spatial equilibrium model then is used to show that targeted export subsidies can be used to increase the subsidizing country's welfare by exploiting transportation cost differences and the elasticity of excess supply of competitors or of markets supplied by competitors through subsidization of shared markets. In addition, an empirical model of the world wheat market is used to illustrate the theoretical conclusions.

TARGETED AGRICULTURAL EXPORT SUBSIDIES AND SOCIAL WELFARE

The decline in U.S. agricultural exports and the loss in U.S. export market share in the 1980's has renewed the call for export subsidies on U.S. agricultural products. Sometimes export subsidies are proposed as an option to offset the injurious effects of a strong U.S. dollar on the agricultural sector. Export subsidies are also advocated as a policy to offset U.S. loan rates set above world market clearing prices. The Reagan Administration has also proposed export subsidies as a tool for forcing the European Community to change its agricultural policies (Block).

A well-known result of trade theory is that a global-uniform export subsidy reduces the social welfare of the subsidizing country when the welfares of all economic agents in the subsidizing country are equally valued. Paarlberg has shown that a global subsidy can increase welfare if the welfares of various agents are valued differently, and if direct subsidization of those agents is politically infeasible. However, most agricultural export subsidies are not global and uniform, but rather are targeted toward specific countries. In that case, price discrimination in international markets may permit exploitation of market power. The U.S. Export Enhancement Program of May 1985 is one example of a targeted export subsidy. Public Law 480 (food aid), export credit (GSM 100), export credit guarantees, and blended credit programs have also been used to price discriminate between importers.

Using a single-product partial equilibrium model, Sharples argues that a targeted export subsidy can be welfare increasing. Even if the United States is prevented from taxing exports by the Constitution, it can still exploit different nations' excess demand elasticities, thereby reaping the

benefits of discriminatory pricing through a system of targeted subsidies. By subsidizing relatively elastic markets, the United States is in effect taxing countries with relatively less elastic excess demand schedules, thereby, raising U.S. welfare along with agricultural prices and income.

This article formalizes the hypothesis offered by Sharples. It demonstrates that a targeted export subsidy can increase the social welfare of the subsidizing country at low levels of subsidy in a standard general equilibrium model of international trade. The choice of subsidy targets and potential gain from subsidization depend on the relative magnitude of income effects in demand relationships of the subsidizing country, the targeted country, and the Rest-of-the-World.

The second section of this paper uses a partial equilibrium framework to develop additional circumstances under which targeted subsidies emerge as optimal trade policies. The partial equilibrium approach more easily permits examination of a market with several importers and competing exporters, and also allows treatment of the implications of transportation cost differentials in a competitive spatial equilibrium framework. First, an analogous case to the general equilibrium result is presented for this spatial equilibrium model. Then the effects of using targeted subsidies in markets shared with other exporters are considered. These results suggest that the income effects also play a critical role in the partial equilibrium model, through the importance of import demand elasticities to setting optimal subsidy levels. Further, the results show that the interaction of the subsidizing country with other exporting countries, particularly exporters who hold stocks which are price responsive, acts to increase the elasticity of excess demand faced in shared markets. Hence, competitive behavior of price elastic competitors increases the likelihood of benefits

from targeted subsidies. The spatial equilibrium model results also emphasize the role of transportation charges in setting subsidies. Even though a country may not supply a particular market due to transportation cost disadvantages, the country can exploit the price responsiveness of that importer's excess demand by subsidizing in a market shared with the exporting country supplying that market. Further, by re-routing trade patterns of other exporters away from the unsubsidized optimum, a targeted subsidy can exploit transportation costs to drive wedges between competing exporter's prices. Capturing markets from or punishing competitors, as is the case of proposed retaliation to EEC target prices requires this exploitation of transport cost differentials.

The final section presents the results of an empirical spatial equilibrium model of world wheat trade. The model is used to evaluate alternative optimal U.S. targeted subsidy schemes. These results demonstrate how the transportation costs and excess demand elasticities determine which countries should receive subsidies in order to maximize U.S. objectives. The results also show that the level of optimal subsidies is small for this market. They also show that at these low levels of subsidy the United States can experience a welfare gain, but the gain is very small considering the trade distortions which result. Finally, the empirical results demonstrate the importance of China and the Soviet Union to the success of a targeted subsidy program. China is assumed to have limited foreign exchange so that its allocation of foreign exchange to wheat imports is fixed and the implicit income elasticity equals one. Hence, it receives a subsidy because its income effect, caused by the subsidy reducing the border price, is relatively large. Despite a perfectly inelastic excess

demand, the Soviet Union is subsidized because of transportation cost differentials between exporters and the fact that model results suggest it can be supplied at little additional cost by several other exporters. By subsidizing the USSR, the United States can exploit the elasticity of countries it does not supply by forcing other exporters to shift out of the Soviet market. Subsidizing the USSR also prevents competitors who were displaced from other markets from recapturing market share in the Soviet market. These two countries represent the extreme cases -- an elastic excess demand relationship for China and exploiting transportation costs in the case of the Soviet Union.

GENERAL EQUILIBRIUM MODEL

This section demonstrates the conditions under which a targeted export subsidy can improve the welfare of the subsidizing country in a standard general equilibrium model of international trade. The model used is similar to the framework presented in Dixit and Norman. The world is divided into three countries -- the subsidizing country, the targeted country, and the Rest-of-the-World. Each country is described by a national income identity based on balance of payments equilibrium. The model is closed by a market clearing identity.

The national income identity for each nation requires that income earned in production equals income spent in consumption. Hence, the balance of trade is zero. Income derived from production activities is given by the revenue function which is defined as:

$$(1) \quad R(P,V) = \max_{Q} \{PQ;\ (Q,V) \text{ feasible}\}$$

where V is a vector of non-traded net inputs of primary factors, Q is a vector of traded net outputs, and P is a vector of output good prices. The

revenue function as given by (1) assumes a convex production technology, and that the economy is free of factor market distortions.

Like its relative, the profit function, differentiation of the revenue function (1) gives useful results. The first derivative of the revenue function with respect to an output price is the supply function ($Q_i(P,V)$), which is non-negative. The second derivative of the revenue function with respect to an output price is the slope of the supply function, which is non-decreasing due to the convexity assumption. The first derivative of the revenue function with respect to the endowment of a factor is the factor price, which is also non-negative.

Consumers are assumed to minimize the expenditure necessary to achieve a given level of utility. This is given by the expenditure function, which is defined as:

$$(2) \quad E(P,U) = \underset{C}{\mathrm{MIN}} \{PC;\ F(C) \geq U\}$$

where C is a vector of goods consumed, U is the level of utility, and f(c) is a strictly quasi-concave utility function. The properties of (2) are well-known (Varian). To aggregate across consumers it is assumed that f(C) is homothetic (Gorman). Therefore, E(P,U) represents the expenditure behavior for the entire economy.

These relations establish the national income identities in the three regions which constitute the world. In the subsidizing country national expenditure must equal income earned from production less subsidy costs on trade to the targeted country:

$$(3) \quad E(P,U) = R(P,V) - S(E^*_p(P^*,U^*) - R^*_p(P^*,V^*))$$

where S is the vector of per unit subsidies, and $R_p^*(P^*,V^*)$ and $E_p^*(P^*,U^*)$ are the first derivative of the revenue and expenditure functions with respect to the price vector in the targeted country which receives the subsidy (denoted by the *). The national income identities in the targeted country and in the Rest-of-the-World equating expenditure and revenue and are:

(4) $E^*(P^*,U^*) = R^*(P^*,V^*)$

(5) $e(p,u) = r(p,v)$

where the lower case letters denote the Rest-of-the-World. The inclusion of the subsidy cost in (3) but not in (4) and (5) is because the latter are evaluated in terms of their internal prices -- P^* and p -- which directly incorporate the subsidy.

The model is completed by adding three more identities. Global market clearing is obtained by using the derivative properties of the revenue and expenditure functions which yield a global commodity balance:

(6) $E_p(P,U) + E_p^*(P^*,U^*) + e_p(p,u) = R_p(P,V) + R_p^*(P^*,V^*) + r_p(p,v)$

This identity (6) states that global demand as given by the first derivatives of the expenditure functions must equal global supply as obtained from the first derivatives of the revenue functions. The final two identities link the prices in the three countries. The price in the targeted country equals the price in the subsidizing country less the specific subsidy (S):

(7) $P^* = P - S.$

By assumption prices for the Rest-of-the-World and the subsidizing country are free of trade distortions, hence, are equal ($P = p$).

Comparative Statics

The welfare effects of the targeted export subsidy are found by differentiating the model while holding factor endowments constant. Recalling the properties of the expenditure and revenue functions, differentiation of the national income identities yields:

$$(7) \quad MdP + E_u dU = -M^* dS - SdM^*$$

$$(8) \quad M^* dP^* + E_u^* dU^* = 0$$

$$(9) \quad mdp + e_u du = 0$$

where M, M^*, and m are row vectors of net imports, and dP, dP^*, and dp are column vectors of border price changes. By rearranging these equations, it can be seen that an increase in the price of the export good raises welfare, as does a decrease in the price of an import good. These effects correspond to the argument by Sharples that the targeted subsidy lowers prices to the targeted buyer, but may also raise the world price, thereby increasing the welfare of both the buyer and possibly competing exporters. Welfare of unsubsidized importers would decline, however, so that the welfare change for the rest of the world is ambiguous.

Differentiating the global commodity balance, the price linkages and imports by the targeted country, then substituting, gives a system consisting of the change in subsidizing country's utility and price in terms of the change in the subsidy:

$$(10) \quad (M - (M^* C_y^* - H^*)S)dP + E_u dU = (SH^* - M^*(1 + SC_y^*))dS$$

$$(11) \quad (H + H^* + h - M^* C_y^* - mcy)dp + CyE_u dU = -(M^* C_y^* - H^*)dS$$

where H, H^*, and h are the substitution effects in consumption and production in the subsidizing country, targeted country, and the Rest-of-the-World, respectively. The income effects in the three countries ($\partial C/\partial Y$, where Y is income) are denoted by C_y, C_y^*, and c_y. These effects are introduced into the problem by differentiation of the global commodity balance and imports by the targeted country which yields the terms E_{pu}, E_{pu}^*, and e_{pu}. From the properties of the expenditure function it can be shown that $E_{pu} = E_u C_y$ (Dixit and Norman). The complete procedure is shown in Appendix A.

Equation (10) is the transformed differential equation obtained from the national income identity for the subsidizing country (see (3) and (7)). In the two good case, where good 2 is the numeraire, M and H^* become negative valued scalars, as H^* represents the substitution effects in the targeted country and $-M$ equals exports of good 1 by the subsidizing country in terms of good 2. Good 1 is the commodity receiving the targeted subsidy. The remaining variables and parameters m, M^*, C_y^*, S, and E_u are positive scalars. The first term of equation (10) is the terms-of-trade effect which says that an increase in the relative price of good 1 -- the subsidized export good -- raises the welfare of the subsidizing country. The terms-of-trade effect is countered by the subsidy cost effect given by the right-hand side of equation (10). As the subsidy increases, costs rise and welfare falls. Thus, the net effect of the targeted subsidy depends on the magnitude of the benefits from the terms-of-trade effect compared to the subsidy costs effect.

Equation (11) is the transformed differential equation of the global commodity balance (equation (6)). With the subsidizing country's welfare held constant, the effect of the subsidy is to raise the relative price of good 1.

The discussion of equation (11) held the subsidizing country's welfare constant. However, that effect is the focus of this analysis. To determine the full effect of the subsidy, equations (10) and (11) must be solved for dP and $E_u dU$. The change in the relative price of good 1 is:

$$(12) \quad \frac{dP}{dS} = \frac{H^*(1-C_yS) + C_yM^*(1+SC_y^*) - M^*C_y^*}{H + H^* + h + M^*(C_y-C_y^*) + m(C_y-c_y) + C_yS(M^*C_y^*-H^*)}$$

Inclusion of the effect of the change in the subsidizing country's welfare, $E_u dU$, in the expression for the change in the relative price of good 1 causes an ambiguous result. The sign of the denominator depends on the relationship between the income effect in the subsidizing country, C_y, and those in the other two, C_y^* and c_y. A sufficient condition for the denominator to be negative is that C_y equals zero. If C_y is not zero, but is still less than C_y^* and c_y, the denominator will tend to be negative because the only positive influence is $C_ySM^*C_y^*$.

The sign of the numerator of (12) also becomes ambiguous as a result of including the effect of the subsidy on the subsidizing country's welfare. As is true for the denominator, a sufficient condition for the numerator to be negative is that C_y equals zero. Hence, when the income effect in the subsidizing country is zero, the targeted export subsidy

unambiguously raises the relative world price of the subsidized good ($P_1 = p_1$).

Weaker generalizations can also be formed from (12). If the income effect in the subsidizing country is low, as would be true for an agricultural good exported by a developed country, and if the level of subsidy and volume of trade are small, then the targeted subsidy will probably raise the world market price.

Another result obtained from (12) is that the change in the relative world price of the subsidized good is less than the change in the subsidy. This result can be determined by testing whether the absolute value of the numerator in (12) exceeds the absolute value of the denominator. This test shows that:

$$(13) \left|\frac{dP}{dS}\right| < 1.$$

Hence, the change in the relative world price is less than the change in the targeted subsidy.

Solving the system of differential equations, (11) and (12), for the change in the subsidizing country's welfare, $E_u dU$, gives:

$$(14) \quad \frac{E_u dU}{dS} = \frac{[(SH^*-M^*-M^*SC_y^*)(H+h) + M^*m(c_y-C_y^*) + Smc_y(M^*c_y^*-H^*) + mH^*]}{[H+H^*+h+M^*(C_y-C_y^*)+m(Cy-cy) + C_yS(M^*C_y^*-H^*)]}$$

As with the price effect, the effect of the targeted subsidy on the subsidizing country's welfare is ambiguous. Consistent with the previous discussion the denominator, is assumed to be negative. The first term in (14) represents the effect of the subsidy operating through the substitution effects in the subsidizing country and the Rest-of-the-World. If the sub-

sidy causes the world price to rise, then the result is to encourage production and discourage consumption in the subsidizing country and the Rest-of-the-World. The substitution and income effects in the targeted country are captured by the last two terms of the numerator in (14). As with the first term, the substitution and income effects in the third term exert a negative influence on the subsidizing country's welfare. The substitution effects in the targeted country, as given by the fourth term, positively influence the subsidizing country's welfare.

The effect of the second term of (14) on the subsidizing country's welfare is ambiguous. Exploiting differences between the income effect in the Rest-of-the-World and in the targeted country increases the subsidizing country's welfare. The second and fourth terms are analogous to a price discriminating monopolist exploiting differences in demand elasticities to increase profits. If the price effect in the targeted country exceeds that income effect in the Rest-of-the-World, the potential for a welfare gain exists.

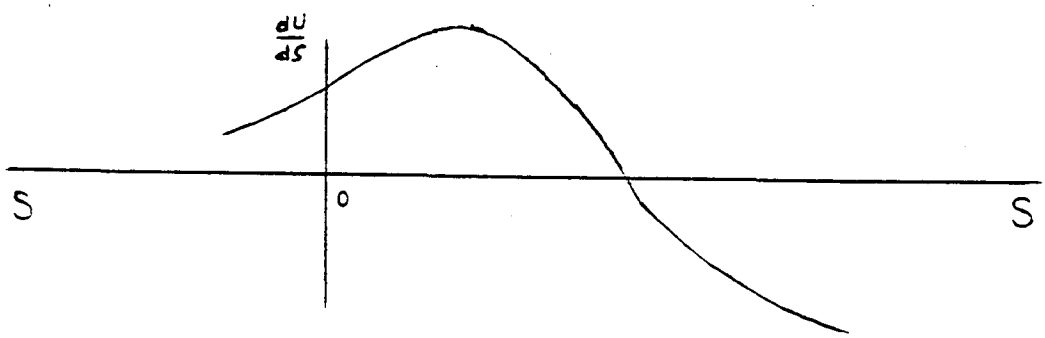
The most favorable conditions for a welfare gain for the subsidizing country exist for low values of the subsidy. If the initial subsidy is zero then (14) reduces to:

$$(15)\quad \frac{E_u dU}{dS} = \frac{1}{\Delta}\left[m + [(m(c_y - C_y^*) - (H+h) + mH^*]\right.$$

where Δ is the denominator in (14). If the income effect in the targeted country is large and dominates the substitution effects in the two regions (H+h) and the Rest-of-the-World's income effect, then the subsidizing country's welfare will rise as S increases. Additional increases will bring the other welfare-reducing terms into play, thereby causing the increase in welfare to slow and eventually become negative. The result is a pattern

shown in Figure 1 where at low subsidy levels an increase in the subsidy raises welfare and as the subsidy increases the increase in welfare diminishes and ultimately turns negative.

Figure 1: The Effect of Increasing Levels of Targeted Export Subsidies on the Change in Welfare.



Another aspect of the targeted subsidy is that other exporting countries can experience a welfare gain at the expense of unsubsidized importers. This can be seen from equation (9) if the Rest-of-the-World is disaggregated into exporters and importers. The targeted export subsidy raises the world price, hence, causes $e_u dU$ to increase for $m < 0$ (exporters) and decrease for importers ($m > 0$).

PARTIAL EQUILIBRIUM SPATIAL TRANSPORTATION MODEL

The general equilibrium model presented above shows that an exporting country can, under certain conditions, exploit differences in income effects, hence price elasticity, in order to increase its welfare through discriminatory pricing. Those conditions are similar to the results of Sharples, which suggest targeting the most elastic markets. They qualify his results, however, by demonstrating that elastic net import demand as a

consequence of income effects and not just substitution effects in the targeted country is necessary for welfare gain to the subsidizing country. Targeting markets where substitution effects, not income effects, lead to large elasticities generally results in compensating losses in second markets. However, the assumptions of the general equilibrium model prevent exploration of certain factors which can also be critical to increasing the subsidizing country's welfare. Particularly important are the sharing of markets with other exporters, transportation costs, and stock behavior. To insure tractability in the general equilibrium framework, the number of trading countries or regions was limited to three and adjustments due to transportation linkages were ignored. Furthermore, the expenditure and revenue function approach precludes consideration of dynamics between periods resulting from stockholding. And stockholding behavior of competing exporters may be the most price responsive element in many agricultural markets in the short run. Government intervention by importers and exporters can also alter the net trade elasticities relative to those implicit in the expenditure and revenue function approach though limited price transmission (Bredahl, Collins and Meyers). While in most cases the net trade elasticity is lowered by the intervention, in the case of the People's Republic of China, where a fixed foreign exchange allocation to the subsidized country is assumed, it may in fact be raised. Government objectives for agricultural policy may also differ from the utility measure employed above -- if specific agents (i.e., farmers) are targeted by this policy.

It can be shown that importer and competing exporter behaviors may be reduced to price responsive net trade models. Only the cross-commodity substitution effects of subsidization are lost by examining this issue in a partial equilibrium framework. A tradeoff must be made between treatment

of these cross-commodity effects and the richness of a multi-region model with government intervention. Therefore, this section builds on the general equilibrium model results in several ways using a single commodity partial equilibrium spatial transportation problem. First an optimal targeted export subsidy condition analogous to the general equilibrium model (14) is developed using net trade functions depending upon the price of a single commodity. The partial equilibrium model explicitly considers the different welfare impacts when the targeted countries and the Rest-of-the-World region are disaggregated into several importers and exporters. The spatial model also allows for strategic interaction among exporters when markets are shared, and for imperfect price transmission. Finally, it considers the role of transportation cost in exploiting the excess demands of importers not supplied by the subsidizing exporter.

Basic Model

The theoretical model is designed to analyze the market impacts and welfare implications of targeted export subsidies. Several simplifications are employed to insure tractability and interpretability of the results. The model assumes that there are n exporting countries and m importing countries interacting in a single market. Each country is potentially price responsive and its behavior is represented by a reduced form -- excess demand equation defined as:

(16) $X_i = X_i(P_i) \qquad x\ i = 1, \ldots, n$

(17) $M_j = M_j(P_j) \qquad x\ j = 1, \ldots, m$

where X_i denotes exports of the commodity, in physical units by country i, M_j denotes imports of the commodity in physical units by country j. The

real border prices in the various exporting countries are given by P_i, while those in the importing countries are denoted P_j. Equations (16) and (17) are closely related to the commodity balance of the general equilibrium model. If P_i and P_j are normalized with respect to the price of all other goods and if importer j is an open economy without intervention, then (16) and (17) are equivalent to the first derivatives of the revenue and expenditure functions for each country.

Denote X_{ij} as the flow of exports of the commodity from exporter i to importer j. The total level of imports by the jth country is the sum of commodities purchased from all of the i exporting countries:

$$(18) \quad \sum_{i=1}^{n} X_{ij} = M_j(P_j) \qquad j = 1, \ldots, m.$$

where there are n exporters and m importers. Similarly, total exports by country i is the sum of shipments to the individual importing countries:

$$(19) \quad \sum_{j=1}^{m} X_{ij} = X_i(P_i) \qquad i = 1, \ldots, n.$$

Border prices are linked among the countries by transportation charges and subsidies. The transportation charge of shipping the commodity from country i to country j is given by T_{ij}, while the subsidy on that flow is denoted by S_{ij}. If S_{ij} is negative, then that flow is taxed. Unlike the general equilibrium model, which only allowed a subsidy on exports from the subsidizing country to the targeted country, this formulation potentially allows for a different subsidy on each commodity flow. The linkage which results is:

$$(20) \quad P_i + T_{ij} - S_{ij} - P_j \geq 0 \qquad i = 1, \ldots, n; \; j = 1, \ldots, m.$$

The standard spatial equilibrium complementary slackness conditions for a competitive equilibrium are given by:

(21) $X_{ij}(P_i+T_{ij}-S_{ij}-P_j) = 0 \qquad i = 1, \ldots, n;\ j = 1, \ldots, m$

The spatial model can be formulated to determine the optimal level of the welfare increasing targeted export subsidy for country 1 (S_{1j}). To insure tractability all S_{ij} for $i \neq 1$ (subsidies of other exporters) are assumed to be exogenously determined, while S_{1j} is treated as the optimal subsidy to be determined. The excess cost of exporter i in import market j, as given by equation (20), must be greater than or equal to zero at all times, and will be equal to zero whenever exporter i supplies some or all of country j's imports (equation (21)).

Equations (18)-(21) constitute a model of the market within which exporter 1 must operate. Given a set of subsidies and market conditions, all prices and trade flows are determined. The problem facing exporter 1 is to select a set of export subsidies which maximize its objective subject to the market conditions given by (18)-(21).

An individual country has several possible objectives. Maximization of economic surplus, export revenue, export volume, or farmer income (net of the subsidy cost) are possible objectives. For an exporting country, with some reasonable assumptions, each of these measures can be expressed as a monotonically increasing function of the border price -- $F(P_1)$. This is shown in the general equilibrium model for social welfare by equation (10) in which social welfare is directly related to the price change and the change in the subsidy.

In the partial equilibrium model, if country 1's objective is to maximize export revenue, then the objective function is $F(P_1) = P_1E((P_1)$. If

the country wants to maximize export volume, then the objective function is $E_1(P_1)$. For the standard economic surplus maximization problem, an increase in the border price in an exporting country increases producer surplus more than consumer surplus falls, thereby, increasing net welfare. For an importing country, the opposite occurs for as the border price rises consumer surplus falls more than producer surplus rises. In either case, the border may be used as a proxy to indicate the change in welfare. Welfare may be calculated by integrating over the excess supply (demand) curve to yield $F(P_1)$. Each of these is subsequently reduced by the subsidy cost interval.

Which objective is appropriate for selecting the optimal targeted subsidy is difficult and requires knowledge of policymaker behavior and the effects of lobbying behavior. The general equilibrium model presented in the first section is based on social welfare maximization as given by the function f(C). The corresponding partial equilibrium objective is economic surplus. But for a policy whose goal is farmer welfare improvement producer surplus or export (revenue) maximization may be more appropriate. This formulation adopts a general specification of maximizing an objective function $F(P_1)$ less subsidy costs:

$$(22)\ \text{MAX}\ F(P_1) - \sum_{j=1}^{m} S_{1j}X_{1j}$$

where $F(P_1)$ is one of the above functions. Theoretical results are obtained using this function, but specification of a specific subsidy rule requires selection of a particular objective function.

Targeted Versus Uniform Subsidies

It can be easily shown that a targeted export subsidy always dominates a global export subsidy (i.e., optimal targeted subsidies provide a greater value for the objective function than the optimal uniform subsidy). To model the global subsidy, an additional constraint is added to the problem which requires all S_{1j} to have a common value -- S for all importers ($S_{1j} = S$). Adding a constraint to an optimization problem either lowers or leaves unchanged the objective function value. A global and a targeted export subsidy will perform equally only when the optimal targeted subsidies are equal for all importers. Given differing transportation costs and price elasticities, there will always be some set of targeted subsidies which will give at least as good and probably a preferred outcome.

Determination of Optimal Targeted Subsidies

To determine optimal targeted export subsidies, the problem discussed above is written as a LaGrangian:

$$(23)\ \text{MAX } L = F(P_1) - \sum_{j=1}^{m} S_{1j}X_{1j} - \sum_{i=1}^{n} e_i\left(\sum_{j=1}^{m} X_{ij} - X_i(P_i)\right)$$

$$- \sum_{j=1}^{m} m_j\left(M_j(P_j) - \sum_{i=1}^{n} X_{ij}\right)$$

$$- \sum_{i=1}^{n} \sum_{j=1}^{m} p_{ij}(P_j - P_i - T_{ij} - S_{ij})$$

$$- \sum_{i=1}^{n} \sum_{j=1}^{m} c_{ij}X_{ij}(P_j^* - P_i - T_{ij} + S_{ij})$$

The following interpretations of the LaGrangian multipliers aid interpretation of the results. The cost (benefit for exporter 1) resulting from

a one unit increase in exports by country i is e_i. That is, if there is an autonomous outward shift in country i's exports, country i's exports will rise and its price will fall. The LaGrangian multiplier, e_i, equals (minus) the loss to the specified objective for each such increase of one unit (quantity). This multiplier is expected to be negative, but is not restricted in sign, since the constraint is an equality. Similarly, m_j represents the cost arising from a one unit autonomous expansion in excess demand by country j. As X_{1j} increases so does country 1's price. Since an increase in X_{1j} increases the price, hence, the exporter's welfare, this multiplier is expected to be negative (a benefit). The cost associated with suboptimal trade flows is c_{ij}. If exporter i faces an excess cost in market j (equation (20) holds as a strict inequality) and supplies that market anyway, then c_{ij} is the loss to exporter 1 for each unit of excess cost paid. The multiplier p_{ij} is the increased cost from a unit increase in the transportation cost disadvantage to market j. It can also be interpreted as the loss in exporter i in market j resulting from exporter i reducing price one unit. Hence, it reflects losses caused by competitive price adjustments. Whenever X_{ij} equals zero, p_{ij} is positive. If $X_{ij} > 0$, then $p_{ij} = 0$.

From the Kuhn-Tucker equations shown in Appendix B, there is an excess cost for exporter 1 only when $X_{ij} = 0$, hence, the subsidies are:

(24) $S_{1j} = -e_1 + m_j$

Further from (B5) and (19):

$$(25)\ e_1 = (1/\frac{\partial X_1}{\partial P_1})\ (\frac{dF}{dP_1} + X_1(P_1))$$

For a strongly increasing benefit from an increase in exporter 1's border price, e_1 is negative. There is a benefit from increased exports and revenues. If economic surplus is the objective, the second term dominates the first and e_1 is positive. That case corresponds to the situation where the optimal policy is an export tax. If the market solely belongs to exporter 1, then (B3) gives:

$$(26)\ m_j = M_j/\frac{\partial M_j}{\partial P_j^*} < 0;\ \text{and}\ X_{ij} = M_j$$

While (26) is always negative, when market j is more elastic, the slope of the excess demand function is greater in absolute value and m_j is less negative. Hence, the larger subsidies are offered to the more elastic markets.

Combining (26) and (25) as shown by (24) demonstrates the importance of the elasticities of excess demand in the jth importer and excess supply by exporting country 1. These elasticities are comprised of the substitution and income effects which also appear in the conditions derived for the general equilibrium model ((12) and (14)). In that model the condition for a positive welfare gain to the subsidizing country depended on the relative income effects, which increased the elasticity via the Slutsky equation and the substitution effects in the targeted country. In this partial equilibrium model, the subsidies are targeted to countries with the more elastic excess demand functions. Thus, there is a correspondence between the two models -- countries with large income and substitution effects (price

responsiveness) are targeted and result in increased welfare to the subsidizing country.

Shared Markets and Transportation Costs

Thus far, both the general equilibrium and partial equilibrium models have assumed that the subsidizing country is the sole supplier to the targeted country. Relaxing that assumption produces additional circumstances when targeted export subsidies are optimal.

When a market is shared with a competing exporter, and if the competitor supplies only that market, then (26) can be rewritten as:

$$(27)\quad m_j = X_{ij}/(\partial M_j/\partial P_j - \partial X_i/\partial P_i)$$

The expression for e_1 remains the same. Hence, the set of targeted export subsidies is given by substituting (25) and (27) into (24). Equation (27) shows that a market may appear to be more elastic if the quantity exported to that market by country 1 adjusts to price changes resulting from the withdrawal of the competitor in addition to adjusting to an excess demand expansion. This is especially true if $\partial X_i/\partial P_i$ is large due to stockholding behavior. For example assume that the importer is the Soviet Union and that country has a nearly perfectly inelastic excess demand. According to (26), m_j will be highly negative, and it is very unlikely that e_1 will be sufficiently negative to justify a welfare increase in U.S. subsidy. If, however, the Soviet Union may be supplied by another exporting country with a relatively elastic excess supply due to that nation's stock holding behavior (possibly the case for Canada, see Sharples). Then the absolute value of m_j will fall -- m_j is less negative -- and the likelihood of a positive subsidy increases as long as $e_1 < 0$. Thus, even a market which

would not receive a subsidy if supplied only by exporter 1 may be a candidate for a subsidy when shared. This condition is why most targeted subsidies are directed at shared markets in the empirical results.

If the competing exporter -- exporter i -- supplies another market not shared with exporter 1, the price responsiveness facing country 1 is further increased by country i's ability to expand into that other market. Hence, equation (26) becomes:

$$(28) \quad m_j = X_{ij}/(\partial M_j/\partial P_j - \frac{\partial X_i}{\partial P_i} + \partial M_k/\partial P_k)$$

where k is the importing country not supplied by exporter 1. To illustrate this situation, assume the jth country is the Soviet Union with little or no price elasticity, and that the competing exporter is the European Community -- also with little or no price elasticity. Further, assume that the EC is the sole supplier of country k (say Spain) where the excess demand is assumed to be elastic. According to (26) and (27) country 1 (the U.S.) would not select a subsidy. But under these conditions, m_j would be positive since $\partial M_k/\partial P_k < 0$. Hence, a targeted subsidy to the Soviet Union could still be optimal policy. Country 1 is exploiting the elasticity in a market which it does not supply (Spain) by subsidizing sales to the Soviet Union which it shares with the country supplying Spain -- the EC.

Transportation Linkages

Equation (28) necessitates recognition of the role of transportation costs. Due to transportation cost disadvantages exporter 1 may not supply certain markets. However, it can exploit the elasticity of those markets by subsidizing markets shared with competing exporters. The elasticity of

excess supply by other exporters supplying shared markets is also important in identifying targets.

The transportation cost issue also arises because discontinuous jumps in price occur when an exporter completely displaces another in a shared market. The price linkage equation (20) shows that for a shared market, the subsidized price offered by exporter 1 and the price offered by a competitor will always differ by the transportation cost differential. When the shared market changes, so does the transportation cost differential, because exporter 1 drives a larger wedge between country 1's price and the competitors price. In this competitive market model, this is the only means available to country 1 to raise its border price without the price of competing exporters exactly following that increase. It allows the possibility that country 1's price may increase while exporter 1's price may fall.

As exporter 1 raises its border price (before the subsidy is applied) through a subsidy targeted to one of its own import markets, it can lose a shared market. This will increase the competitor's price, increasing the competitor country's welfare. It may also be advantageous for country 1 to subsidize a market where prior to subsidization, the transportation cost differential is slight and as a result capture a competitor's market. Derivative conditions on marginal adjustments do not clearly show these discontinuous adjustments. An empirical illustration clarifies these issues.

AN EMPIRICAL APPLICATION OF TARGETED SUBSIDIES TO WORLD WHEAT TRADE

The previous two sections have shown that targeted subsidies can be welfare increasing for the subsidizing country depending on the price

responsiveness of net trade. Further, whether a targeted subsidy or tax is the optimal policy depends on the country's objective. Section 2 also demonstrates the importance of markets shared with competing suppliers -- especially other exporters who have elastic excess supplies because of stocks policies. These results show that even if a country faces a transportation cost disadvantage to a particular market, it can exploit that country's excess demand by subsidizing in a shared market.

This section presents an empirical model of world wheat trade which illustrates these issues. The model is a modified version of the world wheat model developed by Holland and Sharples. The model used here is based upon short run competitive equilibrium in the international wheat market. It is assumed that equations 16-19 represent the behavior of that market. Only the U.S. exercises market power in the international market. Each of the remaining 5 exporters and the 20 importers is represented by a linear net trade function. Those functions are based on supply-utilization data from USDA, assumed elasticities of supply, demand, stocks adjustment, and price transmission.

The base data for the model consists of the annual average of data for the importing and exporting regions during the years 1979 to 1981. The major modification of the Holland-Sharples model involved disaggregating Mexico, Egypt, India, and Nigeria from their respective regions and then modeling these nations independently. As the model represents short-run equilibrium wheat supply does not respond to price. Demand and stocks adjustment elasticities are largely from Holland and Sharples. International price linkages utilize the transmission elasticities estimated by Collins to reflect the extent of price insulation due to policy interventions. Transportation costs are assumed fixed.

Table 1 reports the assumed demand, stocks adjustment, and price transmission elasticities plus the derived net trade elasticity used in the net trade functions for the six exporting regions. Base period net trade and border prices are also reported. Table 2 reports similar information for the 20 importing regions. Further details on the world wheat trade model are available from the authors on request.

OPTIMAL SUBSIDY SCHEMES

The world wheat trade model is used in conjunction with three assumed objective functions for the United States -- economic surplus, and farm income maximization (less subsidy costs)[1] -- to examine alternative U.S. wheat export subsidy schemes. Determination of these objective functions is based on the linear net trade model, base year supply-utilization data, and the assumed behavioral parameters for the U.S. reported in Table 1. Optimal subsidy schemes are found by using MINOS (a non-linear mathematical programming package) to maximize the chosen objective subject to the assumed behavior of the world market described above. Policy instruments are the targeted subsidies. Two types of targeted subsidy schemes are examined in this framework:

Uniform: the subsidy per unit (metric ton) is the same for all targeted recipients ($S_{1j} = S_1^*$), while some regions receive no subsidy.[2]

Discriminatory: the subsidy per unit (metric ton) may differ for each targeted recipient.

These experiments illustrate the conceptual points discussed previously. The solutions are compared with the base (no subsidy) case. A sum-

mary of the results for the U.S. are shown in Tables 3 and 4. Table 5 presents the pattern of optimal targeted export subsidies offered by the U.S. according to importing region for the five scenarios examined.

Uniform Targeted Export Subsidy

In this experiment, two solutions are obtained -- one for each objective function. Results from this experiment show that the same set of targeted subsidies (the same solution) is obtained with each of the three objective functions. The optimal U.S. wheat export subsidy is $4.00 per ton and is targeted to Eastern Europe, the Soviet Union, the P.R.C., and East Asia (Table 5). The low value of the targeted subsidy is consistent with the general equilibrium results which suggest welfare gains only for small subsidies. The U.S. price rises by $2.09 per ton while the price of U.S. wheat to those markets is $1.91 per ton lower than the base case. U.S. wheat export volume increases 377 thousand tons with 48 percent of total exports shipped to the subsidized markets (Table 4).

Import prices for Western Hemisphere importers and Japan are higher, but fall for all other importing countries and for competitive exporters. The export prices for competitors fall because the U.S. export subsidy forces them to shift some trade to destinations with higher transportation costs. This result is consistent with the partial equilibrium model developed in section 2, but is not feasible under the assumptions of the general equilibrium model. The wheat price goes up for the Western Hemisphere importers and Japan because the U.S. remains their lowest cost supplier. The U.S. border price rises as a consequence of the subsidy increasing demand for its exports. These countries are not subsidized

because of their low net trade elasticities and because of the U.S. transport cost advantage. The price to other importers falls because they either receive the U.S. subsidy or the U.S. is not price competitive (and other exporter prices fell).

The P.R.C. and Eastern Europe have the most slope to their excess demand function because their governments are assumed to face a binding foreign exchange constraint. Consequently subsidies are targeted to them. This result is consistent with the theoretical results in section 1 where the presence of large income effects in the targeted country potentially increase welfare. It is also consistent with equations (26)-(28), where the price elasticity of excess demand is critical for a positive subsidy value. The Soviet Union has a perfectly inelastic excess demand, yet still receives a subsidy because that market is shared with Canada which has a large excess supply elasticity due to its stocks behavior (see (27)). If the Soviet Union does not receive a subsidy, Canada displaces much of U.S. exports to that market. A similar situation exists in the East Asian market where the U.S. shares the market with Australia. More importantly, by subsidizing the East Asian market, the United States keeps Australia from increasing its share of those markets.

The targeted subsidies do increase U.S. welfare, but the increase is small (Table 3). Farm income increases 1 percent, but after the subsidy cost is subtracted, the increase is negligible. Export revenue also rises only 1 percent -- with the loss in earnings on subsidized sales slightly more than offset by increased earnings on unsubsidized sales.

Discriminatory Subsidies: Economic Surplus Maximization

The previous results showed that a uniform targeted subsidy can increase U.S. welfare -- though very slightly -- in accordance with equation (17). This experiment relaxes the restriction that the subsidy is the same to all targeted recipitent countries. The optimal discriminatory subsidy scheme to maximize economic surplus is quite small, with the largest subsidy being $4.00 per ton to Eastern Europe (Table 5).

The pattern of subsidies in the solution is a consequence of the transportation costs and net trade elasticities. As shown in equation (28) the pattern of shared markets determines the denominator of m_j. By targeting a small $4.00 per ton subsidy to Eastern Europe, the United States imposes a wedge between the two exporter's prices -- the U.S. price is $1.68 higher while that of Canada is $2.30 per ton lower (Table 4). This subsidy allows the U.S. to capture a larger share of the slightly expanded Eastern European market. Similarly, the United States uses a $3.29 per ton subsidy to East Asia to capture some of that market from Australia -- the Australian price falls by $1.61 per ton. With the increase in the U.S. price relative to other exporters the U.S. could be priced out of other markets -- specifically the Chinese and Soviet markets. Thus, the U.S. also targets small subsidies to these two countries.

If the subsidies to Eastern Europe and East Asia were larger, the increased price of U.S. wheat relative to its competitors would allow Canada to replace the United States in the Soviet Union and Other Western Europe, and would allow Australia to make inroads in China. In this circumstance the increased marginal cost of the subsidy would exceed the gain in economic surplus. Thus, larger targeted subsidies would reduce the objective function value.

Discriminatory Subsidies: Farm Income Maximization

With this objective a significantly different and more costly targeted subsidy scheme results. The United States targets the largest export subsidy to the P.R.C.[3] ($34.51 per ton in Table 5). At this subsidy level no other exporters are close to competing with the U.S. for the Chinese market.

The increased U.S. exports to China raises the U.S. export price to all other buyers. Therefore, the U.S. faces potential loss of other markets. Consequently, the U.S. offers subsidies to the USSR, Other Western Europe, and the EC to defend against Canadian inroads; and the U.S. offers a subsidy to Brazil to protect against Argentine sales. Subsidies are also targeted to Eastern Europe and East Asia, but these payments directly increase the price wedge between the United States and its competitors. Thus, the subsidy to Eastern Europe stops just short of allowing Argentina to expand into India, East Asia, and Central Africa. The subsidy to East Asia is just short of allowing Australia to gain access to Japan.

The United States pays $384 million in export subsidies -- mostly to China and the Soviet Union (Table 4). Total U.S. wheat exports increase 1.4 million tons above the BASE solution level. China increases imports 1.6 million tons while other importing markets experience no change or small declines.[4] Compared to the base solution, U.S. farm income is $511 million greater while export sales revenue is $581 million greater (Table 3).

Unlike the previous experiments other exporting countries benefit from the U.S. policy because they export more tonnage of higher prices. Importing countries, except the P.R.C., suffer as the prices they face rise. The Chinese receive most of the benefits of the program.

No Subsidies to China or the Soviet Union

The empirical results show that China and the Soviet Union consistently receive the largest subsidies (Table 5). Assuming that subsidies to these two nations are politically unacceptable, another set of scenarios is obtained holding subsidies to these two countries at zero. For these scenarios, the results change considerably. For the scenarios which maximize export revenue and farm income, only U.S. wheat exports to East Asia and Eastern Europe are subsidized. Those two regions account for only 11 percent of U.S. wheat export volume in the base period. Without being able to defend the Chinese and Soviet markets, a large subsidy to Eastern Europe and East Asia would create a large enough price wedge between the U.S. and other exporters to encourage Canadian and Australian expansion in the Soviet and Chinese markets, respectively. In the BASE solution Canada will displace some U.S. exports in the Soviet market if the price differential is reduced by $0.70 per ton. Australia displaces the U.S. in China if the price differential is reduced by $1.80 per ton. The optimal targeted subsidies are $0.70 per ton to Eastern Europe and $1.80 per ton to East Asia -- just enough to keep competing exporters from expanding into the USSR and PRC. The subsidy to Eastern Europe lowers competitors price an equivalent amount, thus, larger subsidies endanger U.S. wheat exports to the USSR and PRC.

For the solution which maximizes U.S. economic surplus, only Eastern Europe receives a subsidy -- $0.70 per ton -- and the U.S. subsidy cost is only $1.15 million (Table 4). The impact on U.S. and world trade is minimal.

By eliminating China and the Soviet Union from the list of possible targets, the optimal subsidy solutions do not significantly increase U.S. welfare compared to the base solution (Table 3).

Alternate Optima

The solutions generated by MINOS indicated that for each targeted subsidy scenario, several alternate optimal solutions exist. That is, several alternative patterns of targeted subsidies would yield the same objective function value. (This is why many importers receive zero subsidies as reported in Table 5.) Further, there are several solutions for which a slightly altered subsidy pattern yielded the same exporter prices but substantially different trade flows and, more importantly, substantially higher total subsidy cost to the U.S. Model solution verification using the Holland-Sharples spatial equilibrium model (altered to correspond to the world wheat model assumed here) yielded both the optimal solution reported and several of the alternative solutions. Changing subsidies less than one cent per metric ton could lead to drastically different trade flow patterns with substantially increased U.S. total subsidy cost.

These problems raise two practical concerns. First, finding optimal subsidies is a tricky business with perfect information, and is complicated even further when uncertainties exist on market behavior. Incorrectly setting subsidies only slightly leads to a much more costly program. Second, the complementarity relationships show that subsidies can be used, if set properly, to force competitors out of markets. The assumption invoked was that competitors will not respond with subsidies of their own to match U.S. subsidies -- they are assumed to behave as pure competitors. An imperfectly competitive response would likely reduce the ability of the U.S. to

use targeted subsidies to drive out competitors, hence further reducing the effectiveness of targeted subsidies.

CONCLUSIONS

This article examines the most frequent form of agricultural export subsidy -- a subsidy targeted to a specific buyer. The first section shows that in contrast to a global export subsidy, a targeted subsidy can increase the welfare of the subsidizing country in the standard general equilibrium trade model. Whether or not welfare is increased depends on the income effect of the subsidy on all other importers compared to that in the subsidized country, and on the strength of the substitution effects in the targeted country. If the targeted country is relatively price and income sensitive, then the exporting country can potentially increase its welfare because the country can adopt a small discriminatory subsidy to exploit differences in substitution and income effects.

The second section extends the analysis by considering additional conditions which the exporter can exploit such as imperfect price transmission, stocks behavior, transportation cost differences, and shared markets. It develops a partial equilibrium optimum targeted subsidy rule where the targeted subsidy level depends on the excess demand and excess supply elasticities. The elasticities include the income and substitution effects as the general equilibrium case and allow for the influences of government and stockholding behavior. The problem is formulated as a spatial equilibrium model which shows the importance of market sharing and transportation costs to the subsidy decision. An exporting country can exploit the excess demand elasticity of a market which it does not supply due to relatively high transportation costs by subsidizing a market shared with the exporter

which supplies the market. Further, a country can exploit the excess supply elasticity of a competitor by subsidizing shared markets even if the excess demand elasticity is zero.

An empirical model of world wheat trade is used to demonstrate these results. The scenarios show that U.S. welfare can be increased with targeted export subsidies. The optimal subsidies are small as suggested by the general equilibrium model. However, these small targeted subsidies produce large disruptions in world trade flows and yield very small net gains in U.S. welfare. Use of targeted subsidies is further complicated due to the result that small changes in subsidies (or in responses of competitors to those subsidies) can drastically change subsidy costs and the benefits realized by the targeted subsidy program.

The results also show that the countries receiving the export subsidies are described by the theoretical conditions in sections 1 and 2. Eastern Europe and China have large income effects, and hence are price responsive in trade. As suggested by the theoretical results in section 1, these regions receive a subsidy. The Soviet Union and East Asia are markets shared with other exporters in which the U.S. uses targeted export subsidies to defend markets against Canada and Australia as argued in section 2.

The general equilibrium analysis argues that targeted export subsidies can improve the welfare of competing exporters. Several of the empirical scenarios confirm this result. Finally, the major importance of the Chinese and Soviet markets to the U.S. subsidy program is demonstrated. Given the empirical model's structure, there is virtually no gain from a targeted export subsidy scheme if those two important markets are ineligible for subsidies.

The empirical results obtained here are sensitive to assumptions made on market structure (i.e., number of importing regions, response of competing exporters, competitive equilibrium), on the behavioral parameters of importers and exporters, and on transportation costs. If one changes the elasticity of net trade demand of one country (such as the P.R.C.), for example, the pattern of optimal subsidies could change substantially. The results shown here, however, demonstrate the principles associated with optimal targeted export subsidization to achieve various U.S. objectives. These also show that the magnitude of the gains available from targeted subsidization are small relative to the market disruptions introduced. While determining the level of optimal subsidies is seen to be difficult. Retaliatory adjustments by competing exporters constitute a further complication to setting optimal targeted export subsidies which merits further investigation.

Table 1: Base Spatial Equilibrium Assumptions - Exporters.

Region	Net Trade	Border Price	Net Trade	Elasticities (∂Z/ P .∂P/Z) Demand	Stocks Adjustment	Price Transmission
	(mil. ton)	(dol./ton)				
United States	42.470	173.99	0.74	-0.2	-1.0	1.0
Canada	16.192	178.19	0.68	-0.3	-1.0	1.0
Argentina	4.110	180.90	0.13	-0.1	-0.2	1.0
EEC-10-Export	12.300	183.59	0.0	--	--	0.0
O.W. Europe-Export	0.800	183.19	0.0	--	--	0.0
Australia	12.034	178.99	0.11	0.0	-0.4	1.0

-- Not applicable

Table 2: Base Spatial Equilibrium Model Assumptions - Importers.

Region	Net Trade	Border Price	Elasticities (∂Z/∂P . P/Z) Net Trade	Demand	Price Transmission
	(mil. tons)	(dol./ton)			
Central America	2.165	187.29	-0.14	-0.35	0.4
Brazil	4.300	190.18	-0.08	-0.25	0.2
Other S. America	3.800	190.49	-0.18	-0.25	0.7
EEC-10	4.500	185.99	0.0	0.0	0.0
O.W. Europe	2.200	189.59	0.0	0.0	0.0
Eastern Europe	5.299	194.19	-0.67	-0.25	0.4
Soviet Union	15.100	196.36	0.0	-0.25	0.0
Peoples Rep. China	11.904	202.92	-1.0	--	--
Japan	5.500	193.54	-0.16	-0.45	0.33
East Asia	6.300	202.19	-0.2	-0.3	0.6
Southeast Asia	1.300	200.19	-0.01	-0.1	0.6
South Asia	2.400	206.99	-0.55	-0.4	0.2
West Asia	6.800	202.75	-0.96	-0.35	0.9
North Africa	5.600	198.19	-0.3	-0.35	0.5
Central Africa	2.067	209.39	-0.25	-0.3	0.6
South Africa	0.100	204.79	-0.9	-0.15	0.3
Mexico	1.035	190.60	-0.69	-0.35	0.54
Egypt	5.400	203.22	-0.12	-0.35	0.26
India	0.701	206.99	-1.0	-0.4	0.73
Nigeria	1.433	209.40	-0.15	-0.3	0.5

-- Not applicable

Table 3: Impacts of Alternative Optimal Targeted Subsidy Schemes on U.S. Welfare in the World Wheat Market.

Outcomes	Net Economic Surplus	Farm Revenue	Export Revenue
	-- million dollars --		
Scenarios:			
Base	4566	11518	7389
	(Change relative to base)		
Uniform Targeted Subsidy	8	138	155
Discriminatory Subsidies			
Economic Surplus Max	15	111	125
Farm Income Max	-51	511	581
Excluding USSR and PRC:			
Economic Surplus Max	8	15	16
Farm Income Max	7	22	24

Table 4: U.S. Market Impacts of Alternative Optimal Targeted Subsidy Schemes.

Scenario	U.S. Export Price	U.S. Export Volume	Export Subsidy Cost
	(dol./ton)	(thd. tons)	(mil. dol.)
Scenario:			
Base	173.99	42470	0
	(Change relative to base)		
Uniform Targeted Subsidy	2.09	377	82
Discriminatory Subsidies			
Economic Surplus Max	1.68	304	57
Farm Income Max	7.71	1393	384
Excluding USSR and PRC:			
Economic Surplus Max	0.22	40	1
Farm Income Max	0.33	59	7

Table 5: Optimal Targeted Export Subsidies Offered by the United States -- by Importing Region.

Region	Scenario: Uniform	Discriminatory: Econ. Surplus Max	Discriminatory: Farm Income Max	Excluding USSR and PRC: Econ. Surplus Max	Excluding USSR and PRC: Farm Income Max
	-- (dol./ton) --				
Central America	0.0	0.0	0.0	0.0	0.0
Brazil	0.0	0.0	0.41	0.0	0.0
Other S. America	0.0	0.0	0.0	0.0	0.0
EEC-10 Import	0.0	0.0	1.92	0.0	0.0
O.W. Europe Import	0.0	0.0	3.32	0.0	0.0
Eastern Europe	4.00	4.00	7.30	0.70	0.70
Soviet Union	4.00	3.31	6.62	0.0	0.0
Peoples Rep. China	4.00	1.50	34.51	0.0	0.0
Japan	0.0	0.0	0.0	0.0	0.0
East Asia	4.00	3.29	6.60	0.0	1.80
Southeast Asia	0.0	0.0	0.0	0.0	0.0
South Asia	0.0	0.0	0.0	0.0	0.0
West Asia	0.0	0.0	0.0	0.0	0.0
North Africa	0.0	0.0	0.0	0.0	0.0
Central Africa	0.0	0.0	0.0	0.0	0.0
South Africa	0.0	0.0	0.0	0.0	0.0
Mexico	0.0	0.0	0.0	0.0	0.0
Egypt	0.0	0.0	0.0	0.0	0.0
India	0.0	0.0	0.0	0.0	0.0
Nigeria	0.0	0.0	0.0	0.0	0.0

Footnotes

[1] Scenarios involving export revenue maximization as an alternative objective were also produced. The results for those scenarios were nearly identical to the results for farm income maximization, as the form of the objective function turns out to be very similar. Only the results for the farm income maximization scenarios are reported, although export revenue is also included in the results summaries.

[2] Uniform and global subsidies differ in that under a global subsidy, all importers supplied by the U.S. receive the same subsidy. There are no importing regions receiving a zero subsidy under a global subsidy scenario. The uniform subsidy is modeled to represent the way in which practical U.S. targeted subsidy programs (i.e., PL 480) are often implemented.

[3] The P.R.C. is the most price responsive importer in the model -- due to the large income effect associated with the assumed foreign exchange constraint.

[4] Some importing regions receiving a targeted subsidy actually face a higher world price than in the BASE solution, and so they import less. Their subsidy is small relative to the subsidy targeted to China and to the increased U.S. export price caused by the expansion of the Chinese market. Hence, the discriminatory subsidy acts like a tax to most importers other than China.

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APPENDIX A

The Effects of a Targeted Export Subsidy on Welfare in a General Equilibrium Model

This appendix presents the details of the general equilibrium model omitted in the text. The general equilibrium model is presented in the text as equations (3)-(6) plus the two price linkage equations for the targeted country and the Rest-of-the-World, respectively:

(A1) $P^* = P - S$

(A2) $p = P$

The differential equation forms of the national income identities are given by (7)-(9). The differential equation form of the global commodity balance is:

$$\text{(A3)} \quad (E_{pp} - R_{pp})dP + (E^*_{pp} - R^*_{pp})dP^* + (e_{pp} - r_{pp})dp + E_{pu}dU + E^*_{pu}dU^* + e_{pu}du = 0$$

where $(E_{pp}-R_{pp})$ are the substitution effects in consumption and production (by Hotelling's lemma) and are denoted H, H^*, h for the three regions. The derivative of the Hicksian demand function H(P,U) with respect to utility is denoted as E_{pu} and can be decomposed as E_uC_y, where C_y is the income effect in the Marshallian demand function and E_u is the inverse of the marginal utility of money (Dixit and Norman). Substituting the differentials of the price linkages into (A3) and collecting the terms yields:

$$\text{(A4)} \quad (H + H^* + h)dP - H^*dS + C_yE_udU + C^*_yE^*_udU^* + c_ye_udu = 0.$$

The next step is to rearrange (8) and (9), and insert the differentials of the price linkages:

(A5) $E_u^* dU^* = -M^* dP + M^* dS;$

(A6) $e_u du = -m dP.$

Substituting (A5) and (A6) into (A4), and collecting the terms gives (11)

(A7) $(H + H^* + h - M^* C_y^* - mc_y) dP + C_y E_u dU = -(M^* C_y^* - H^*) dS$

Equation (10) in the text is obtained from the differential of the subsidizing country's national income identity -- equation (2). That equation includes the term dM^*. From equation (3)

(A8) $M^* = E_p^*(P^*, U^*) - R_p^*(P^*, V^*)$

Differentiation of (A8) when factor endowments, V*, are constant yields:

(A9) $dM^* = E_{pp}^* dP^* + E_{pu}^* dU^* - R_{pp}^* dP^* = H^* dP^* + C_y^* E_u^* dU^*$

Substituting (A5) into (A9) and the differentials of the price linkage to the targeted country expresses dM^* as a function of dP and dS. Substituting this expression into (7) and collecting the terms gives equation (10) in the text:

(A10) $(M - (M^* C_y^* - H^*) S) dP + E_u dU = (SH^* - M^*(1 + SC_y^*)) dS$

Application of Cramer's Rule to (A7) and (A10) gives the results shown as (12) and (14) in the text. The conclusion that $\left|\frac{dP}{dS}\right| < 1$ is from comparing the numerator and denominator of (12). Canceling terms yields:

(A11) $\frac{dP}{dS} \lesseqgtr 1$, if $0 \gtreqless H + h - m(C_y - c_y)$

The absolute value of the substitution and income effects on the right-hand side of (A11) clearly exceeds zero; hence, $\left|\frac{dP}{dS}\right| < 1$.

APPENDIX B

Kuhn-Tucker Conditions for the Spatial Equilibrium Model

This appendix presents the Kuhn-Tucker conditions for the spatial equilibrium model. Those for exporter 1 are expressed separately since terms differ from those of other exporting countries. Imposing the restriction that at optimality P_i, $P_i^* > 0$ gives:

$$\text{(B1)} \quad \frac{\partial L}{\partial P_1} = \frac{\partial F}{\partial P_1} + e_1 \frac{\partial X_i}{\partial P_1} + \sum_{j=1}^{m} (p_{1j} + c_{1j}X_{1j}) = 0$$

$$\text{(B2)} \quad \frac{\partial L}{\partial P_i} = e_i \frac{\partial X_i}{\partial P_i} + \sum_{j=1}^{m} (p_{ij} - c_{ij}X_{ij}) = 0; \; i = 2, \ldots, n$$

$$\text{(B3)} \quad \frac{\partial L}{\partial P_j^*} = -m_j \frac{\partial M_j^*}{\partial P_j^*} - \sum_{i=1}^{n} (p_{ij} + c_{ij}X_{ij}) = 0; \; j = 1, \ldots, m$$

$$\text{(B4)} \quad X_{1j} \frac{\partial L}{\partial X_{1j}} = X_{1j}(-S_{1j} - e_1 + m_j - c_{1j}(P_j - P_1 - T_{1j} + S_{1j})) = 0$$

$$\text{(B5)} \quad X_{1j} \geq 0; \; \frac{\partial L}{\partial X_{1j}} \leq 0; \; j = 1, \ldots, m$$

$$\text{(B6)} \quad X_{ij} \frac{\partial L}{\partial X_{ij}} = X_{ij}(-e_i + m_j - c_{ij}(P_j - P_i - T_{ij} + S_{ij})) = 0$$

$$\text{(B7)} \quad X_{ij} \geq 0; \; \frac{\partial L}{\partial X_{ij}} \leq 0; \; i = 2, \ldots, n; \; j = 1, \ldots, m$$

$$\text{(B8)} \quad S_{1j} \frac{\partial L}{\partial S_{1j}} = S_{1j}(-X_{1j} - (p_{1j} + c_{1j}X_{1j})) = 0$$

$$\text{(B9)} \quad S_{ij} \geq 0; \; \frac{\partial L}{\partial S_{ij}} \leq 0; \; j = 1, \ldots, m$$

Additional Kuhn-Tucker conditions include the constraints of the problem as appear in (23).