Agricultural Resource Conservation and Trade Policies:
Are they Complementary or Inconsistent?

by

Katherine Reichelderfer and Robert G. Chambers*

*Katherine Reichelderfer is Associate Director, Natural Resource Economics Division, Economic Research Service, USDA. Robert G. Chambers is Professor, Dept. of Agricultural and Resource Economics, University of Maryland.

Selected paper presented at annual meetings of the American Agricultural Economics Association, East Lansing, Michigan, August 1987.

Agricultural Resource Conservation and Trade Policies: Are They Complementary or Inconsistent?

The 1985 Food Security Act is unique in several respects. It sets forth a plan to systematically reduce commodity loan rates and target prices over time. And it contains targeted conservation provisions which are consistent with but separate from commodity programs. Both of these new farm legislative approaches reflect public concerns for the future of U.S. agriculture. Loan rate reduction is purported to increase "competitiveness" by bringing domestic commodity prices more in line with world market prices. The conservation provisions address society's increasing concern with the effects of soil erosion on water quality and long term agricultural productivity. But are these two policy thrusts consistent with one another?

It is popularly contended that the U.S. "exported its soil" during the 1970's boom in agricultural export demand. This belief implies an accepted linkage between soil erosion and trade and, therefore, some potential relationship between conservation policy and trade opportunities. But, do attempts to legislate social valuation of natural resource complement or conflict with efforts to increase trade competitiveness?

We apply an intertemporal extension of the standard Ricardo-Viner model to address this question. First, the elements and primary effects of current conservation policies on factor employment are reviewed. Comparative static implications and comparative dynamic results from the model are used to illustrate possible outcomes associated with these policies in a relatively stylized and simplified setting.

Conservation Policy Instruments

A primary motivation for government intervention in natural resource markets is the difference in private and social valuation of natural resources. These differences arise via market failure in the form of externalities or variation in the social and private discount rates that determine optimal use rates for stock resources. Common conservation policy approaches include quotas, bribes, and taxes, all three of which are currently operative for soil conservation programs in the U.S. As the following examples demonstrate, each approach has unique implications for production.

One way to reduce soil erosion rates is to invest in structures (eg: terraces) which retain soil on the land (i.e., invest in land quality). Structural investments improve the quality and present value of the land by preventing future loss of productivity associated with soil depth. (Investment in time t yields improvement in periods t+1 through t+n.) The Agricultural Conservation Program (ACP) and related programs provide cost-share subsidies to farmers who invest in conservation structures. Thus, they both raise the productivity and reduce the long-run marginal cost of land.

Let's contrast this with a taxation approach. The Conservation Compliance (CC) and "sodbuster" provisions of the 1985 Food Security Act penalize farmers who cultivate highly erodible land without investing in soil conservation measures. The penalty is in the form of loss of eligibility for commodity, credit, and other farm program benefits -- a tax at a level which varies as program benefits vary. At the farm level, the effect of conservation compliance depends upon producer response to the tax. Acceptance of the tax in lieu of making conservation investments increases marginal costs of production by the unit value of the tax. Avoidance of the tax requires unsubsidized investments which also increase production costs but have the longer term advantage of maintaining productivity of land.

As an alternative to inducing in situ soil conservation practices, various quota mechanisms can be implemented to withdraw from production those lands from which soil erosion is most likely to occur. This, in effect, is the approach taken in implementing the Conservation Reserve Program (CRP).

Although a bribe in the form of an income supplementing rental payment is paid to encourage 10-year retirement of highly erodible cropland, the ultimate effect will be a 40-million acre reduction in land availability for agricultural production over the 10-year period. At the same time, the average quality, productivity, and value of land remaining in production are increased, especially if we assume, as Taff and Runge suggest, that low productivity-high environmental sensitivity land is targeted for retirement. The net effect on production in the short term depends upon the extend to which the marginal value of land in production rises relative to marginal cost.

Short-Run Impacts on Gains From Trade

While investment subsidies prevent the gradual leftward shift of aggregate supply schedules relating to land productivity declines, they affect neither the marginal productivity of land nor marginal costs of production in the short-run. On the other hand, taxation (as embodied in CC and Sodbuster) and quotas (as embodied in the CRP) elicit a short-run, leftward shift in aggregate supply. Dicks and Segarra postulate that while CC will result in a parallel supply shift, the CRP will change the slope of the supply function. The combined effects of these two conservation policies on welfare and gains from trade are illustrated in Figure 1.

For a given commodity, S and D are domestic supply and demand, and ES and ED are the exporter's excess supply and importers' excess demand, respectively, before implementation of the conservation policies. Standard trade theory (Letiche, Chambers, and Schmitz) tells us that the net gains from trade at Q and world price P_W are equal to areas m+n (export producer gains) plus areas j+k+l (importers' gains). After implementation of the CRP quota and CC tax, domestic supply shifts from S to S^*, excess supply shifts from ES to ES^*, and Q^* is cleared at higher price P_W^*. The net loss in gains from trade is equal to areas l+n, with export producers losing the difference in surplus between areas n and k, and importers losing areas k+l.

Doering, Schmitz, and Miranowski show that the social costs of soil erosion represent an export subsidy. Thus, the imposition of conservation taxes and quotas is akin to removal of an export subsidy: export producers absorb a portion of the subsidy loss by internalizing the external costs of soil erosion; and some of those costs are passed on to foreign consumers.

In the short-run, then, policies that equate private and social values of depletable natural resources will decrease both volume and gains from agricultural trade. But this gives a very short-sighted view of conservation policies' effects. After all, conservation is a long-term strategy designed specifically to affect intertemporal resource use rates, productivity, and value. Adjustments, over time, in agricultural factor employment and productivity may mitigate or even reverse the short-run effects of conservation policy on trade. These possibilities are more rigorously explored via use of an intertemporal Ricardo-Viner type model.

The Model

The model deals with a three factor-two commodity world. The commodities can be thought of as the agricultural good (y_1), which is exported, and the nonagricultural good (y_2). Each production process requires the committal of two inputs, one of which is specific to the sector in question:

$$y_1 = f_1 (v, A) \qquad (1)$$

$$y_2 = f_2 (v, N) \qquad (2)$$

Where: v is a variable input that is freely traded between the two sectors; A is land, the fixed factor specific to agriculture; and N is a fixed factor specific to the nonagricultural sector. The land input (A) is unique in that it is capable of being augmented over time by investment in land quality. This is the point of departure from the usual Ricardo-Viner model in which all inputs are assumed to be in perfectly fixed supply (Jones).

The land input is comprised of two components: the actual endowment of physical acreage (L) and an augmentation factor (λ), such that:

$$A = \lambda L, \text{ and} \tag{3}$$

$$\lambda G\ (o, \infty) \tag{4}$$

Time is introduced into the model by assuming that λ is a state variable which is predetermined at any time t and evolves according to the following equation of motion:

$$\dot{\lambda}(t) = m(v_1) + n(I) \tag{5}$$

Where: $m(v_1)$ is a land degradation equation implying that the use of the variable input in agricultural production causes deterioration in land quality; and I is investment in land improvements.

In solving this problem, we make a "small country" assumption that allows us to ignore the demand side of the economy. Then, supposing that v and N are in fixed supply, we can see that farmers will maximize according to:

$$\text{Max} \int_0^\infty e^{-\partial t}(p_1 f_1(v,A) - rv - I)dt \tag{6}$$

subject to:

$$\dot{\lambda}(t) = m(v_1(t)) + n(I(t)) \tag{7}$$

$$\lambda(0) = \overline{\lambda} \tag{8}$$

and the other production process is:

$$\text{Max}\int_0^\infty e^{-rt}(p_2f_2(v_2,N)-rv_2)dt \qquad (9)$$

with current-value Hamiltonions:

$$H_1 = p_1f_1\ (v_1,A)- rv_1-I + \mu(m+n) \qquad (10)$$

$$H_2 = p_2f_2\ (v_2,N)-rv_2 \qquad (11)$$

Where: v_1 and v_2 are the amounts of v used in each sector; p_1 and p_2 are commodity prices; r is the price of the variable input; and μ is the shadow price of land quality (λ).

The first order conditions are:

$$\frac{\partial H_1}{\partial v_1} = p_1 \frac{\partial f_1}{\partial v_1} - r + \mu m' = 0 \qquad (12)$$

$$\frac{\partial H_1}{\partial I} = -1 + \mu n' = 0 \qquad (13)$$

$$\frac{\partial H}{\partial v_2} = p_2 \frac{\partial f_2}{\partial v_2} - r = 0 \qquad (14)$$

The following set of differential equations were derived (via formal operations available from the authors) and solved to determine optimal conditions for general equilibrium. 1/

1/ The model is fully developed in: Chambers, Robert G. and Katherine Reichelderfer. (Forthcoming) "Effect of Natural Resource Policies on Agricultural Trade", chapter 6 in (J. Sutton, ed.) Agricultural Trade and Natural Resources: Discovering Critical Linkages, Lynne Rienner Publishers, 1988.

$$\begin{bmatrix} \frac{\partial^2 H}{\partial \mu^2} & \frac{\partial^2 H}{\partial \mu \partial \lambda} \\ \partial - \frac{\partial^2 H}{\partial \mu \partial \lambda} & \frac{-\partial^2 H}{\partial \lambda^2} \end{bmatrix} \begin{bmatrix} d\mu \\ d\lambda \end{bmatrix} = \begin{bmatrix} \frac{-\partial^2 H}{\partial \mu \partial p_1} dp_1 - \frac{\partial^2 H}{\partial \mu \partial L} dL - \frac{\partial^2 H}{\partial \mu \partial p_2} dp_2 \\ \frac{\partial^2 H}{\partial \lambda \partial p_1} dp_1 + \frac{\partial^2 H}{\partial \lambda \partial p_2} dp_2 + \frac{\partial^2 H}{\partial \lambda \partial L} dL \end{bmatrix}$$

Among the interesting relationships that become apparent from this system are those describing the change in steady-state values for land quality and the shadow price of land quality with factors that elicit a change in the price of the agricultural good:

$$(15) \qquad \frac{d\mu^\infty}{dp_1} = \frac{1}{\Delta} \left\{ \frac{\partial^2 H}{\partial \mu \partial p_1} \frac{\partial^2 H}{\partial \lambda^2} - \frac{\partial^2 H}{\partial \mu \partial \lambda} \frac{\partial^2 H}{\partial \lambda \partial p_1} \right\} \geq 0$$

$$(16) \qquad \frac{d\lambda^\infty}{dp_1} = \frac{1}{\Delta} \left\{ \frac{\partial^2 H}{\partial \mu^2} \frac{\partial^2 H}{\partial \lambda \partial p_1} + \left(\frac{\partial - \partial^2 H}{\partial \mu \partial \lambda} \right) \frac{\partial^2 H}{\partial \mu \partial p_1} \right\}$$

$$(17) \qquad \Delta = \frac{\partial^2 v}{\partial \mu^2} \frac{\partial^2 H}{\partial \lambda^2} - \frac{\partial^2 H}{\partial \mu \partial \lambda} \left(\partial - \frac{\partial^2 H}{\partial \mu \partial \lambda} \right) > 0$$

The sign of equation (16) is indeterminant. This becomes particularly critical in its implications for the long-run effects of the CRP; implications which are most easily viewed in terms of the derived long-run demand and supply for land quality. These long-run schedules are illustrated in Figure 2 and are determined by a number of factors, including relative commodity prices, producer discount rates, and the endowment of land.

Intertemporal Impacts

The effect of subsidized investment in conservation structures is fairly straight-forward. This strategy shifts the long run supply curve for land quality to the left (from LS to LS^{**} in figure 2). The shadow value of land quality (μ) increases, thus encouraging both greater use of the variable input (v), which degrades land, and continued investment (I) in maintaining land quality. The net effect is an increased long-term devotion of v to agriculture, with v_2 declining, and a consequential rise in production and export of the agricultural good. Whether this induced increase in the future volume of trade results in any additional gains from trade depends upon the slope and degree of shift of the exported good's excess supply schedule (see Schmitz, Sigurdson, and Doering).

The effect of tax-induced private investment in land quality, via CC and Sodbuster policies, has a similar long-run effect. However, intermediate adjustments shift more of the variable input into the nonagricultural sector as the value of taxes and/or investment lowers the marginal value of v_1 in time t. Over successive time periods, the effect of investment on increases the shadow price of land quality and draws v back into agriculture.

Now, consider what we have found to be the more interesting effect of retiring highly erodible land through the CRP. Long-term land retirement is equivalent to reducing the physical endowment of land (L). In the very short run, when it is impossible to augment land quality, the first response to the CRP and related policies is forced by the fact that land retirement reduces the marginal productivity of the variable factor devoted to agricultural production. This is consistent with the short-term effects illustrated in figure 1.

However, decreasing L tends to reduce the long-run demand for land quality. This happens because each unit of quality already in existence has less physical land to interact with, thus diminishing the marginal productivity of the quality factor. This may be represented by a shift from LD to LD^{*} in figure 2. On the other hand, the long-run supply curve of land quality shifts to the right (LS to LS^*) as L declines because the decline in L decreases the utilization of v in agricultural production. But, decreasing the utilization of the variable factor of production, ceteris paribus, means that the scale of operation starts to decline and, as this happens, the quality of land remaining in production tends to rise.

These results are surprisingly ambiguous with respect to land quality. In the long-run, it is unclear whether quality rises or falls. What is clear, however, is that the shadow value of land quality falls unambiguously. So, if long-run land quality either falls or only slightly increases, we find that use of v in agricultural and, therefore, agricultural production decline.

The system's dynamic adjustment process provides clearer clues as to the fate of agricultural trade related to conservation policies. Our results suggest that if the decrease in L tends to increase land quality, then the shadow price of equity adjusts less in the short-run then it does in the long-run. But, if a decrease in L decreases land quality in the long-run then the shadow price of equity adjusts in the short-run by overshooting the long-run adjustments. And, as a consequence, the short-run adjustments in agricultural production and production of the nonagricultural good also overshoot their long-run adjustment. Nonagricultural production rises more in the short-run than is required for long-run equilibrium while agricultural production declines more in the short-run then is required for long-run equilibrium.

Implications and Conclusions

The consequences for trade of the simple general equilibrium results of conservation policy implementation are somewhat ambiguous. Simple intuition would suggest, and the model supports the case that the new agricultural conservation provisions (CRP, CC, and "sodbuster") by themselves diminish agricultural trade while enhancing nonagricultural trade and nonagricultural income. But, as demonstrated, exceptions to this case are possible for the CRP in the long run.

If conservation policy decisions are considered in light of their impacts on agricultural trade, the preferred approach is subsidization of investments in future land quality. The advantage of this approach is that it improves long-run trade opportunities without affecting short-run competitiveness. Conservation compliance and the CRP, on the other hand, negate some of the gains from trade that are expected to arise from adjustments in loan rates and target prices. But, the long-run effects of the CRP on trade are not clear. These will depend upon a range of factors including the relative prices of production factors and agricultural vis-a-vis nonagricultural goods, the elasticities of supply and demand for land quality, and the degree to which land quality supply and demand schedules shift over time in response to price changes. While the CRP may interfere with trade possibilities in the short-run, it may, under certain conditions, improve the long-run competitive position of U.S. agricultural trade.

Figure 1. Welfare and Gains From Trade Implications of Removal of Conservation Export Subsidy

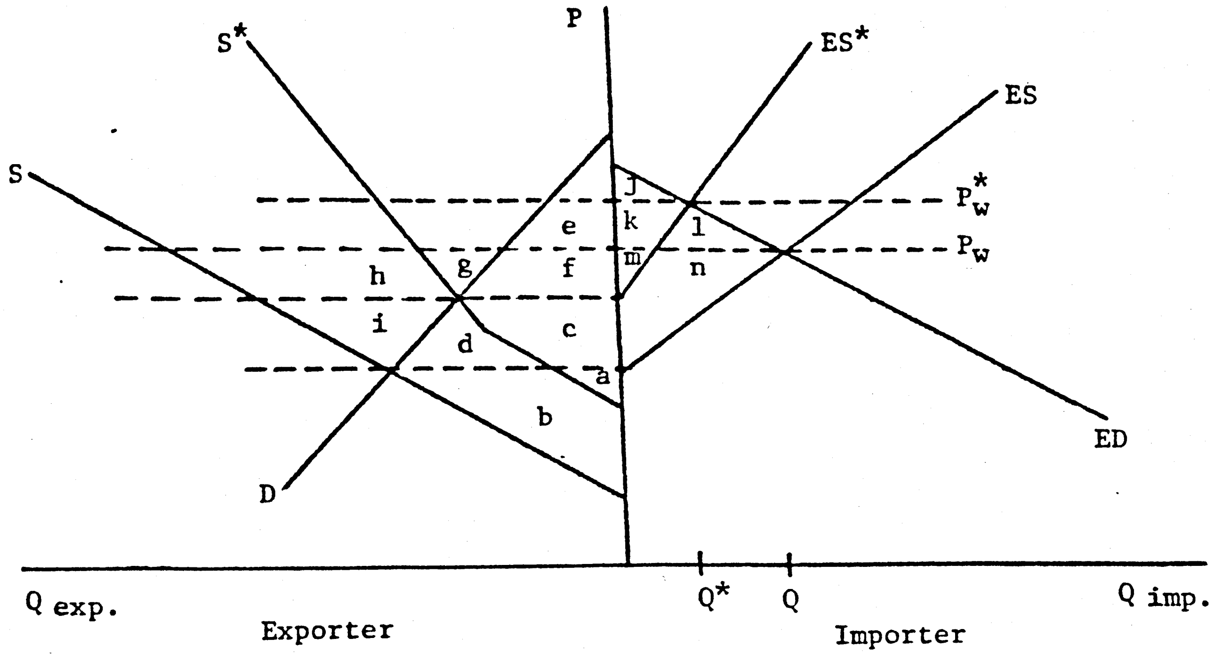
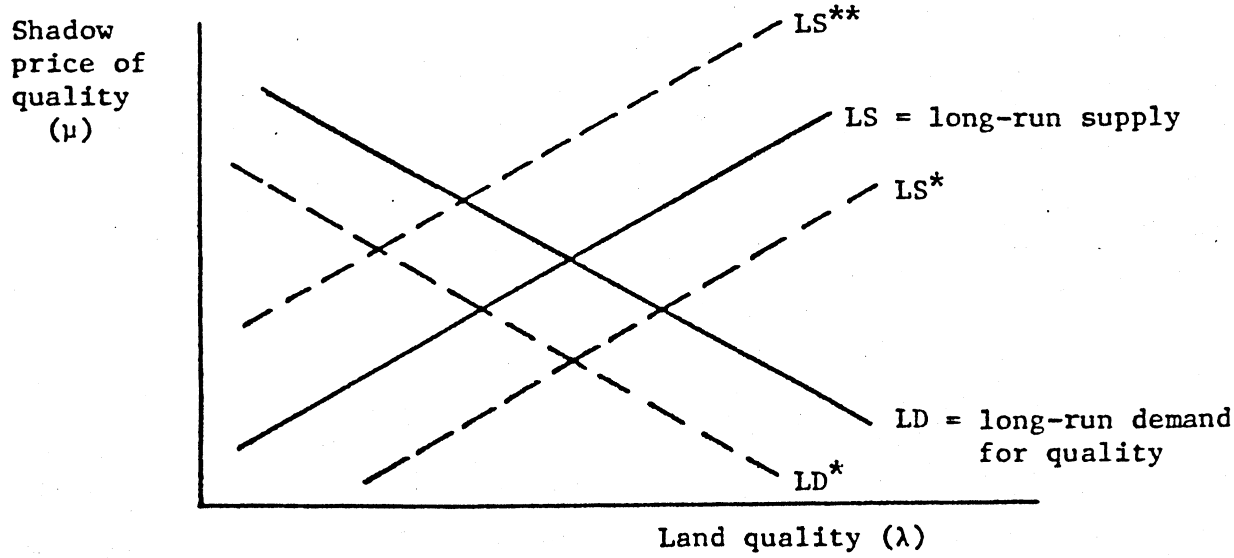


Figure 2. Effects of Land Retirement and Investment on Land Quality



References

Dicks, Michael and Eduardo Segarra. "Welfare Implications of Two Conservation Provisions of the 1985 Food Security Act." Unpublished working paper, Wash. D.C.: Economic Research Service, Feb. 1987.

Doering, Otto, Andrew Schmitz, and John Miranowski. "Farm Costs and Exports." Increasing Understanding of Public Problems and Policies-1983. Oak Brook IL: Farm Foundation, 1983.

Jones, Ronald W. "A Three-Factor Model in Theory, Trade, and History," Trade, Balance of Payments, and Growth, ed. J. Bhagwati, et al. Amsterdam: North Holland, 1971.

Letiche, J. M., R. G. Chambers, and A. Schmitz. "The Development of Gains from Trade Theory: Classical to Modern Literature." International Economic Policies and Their Theoretical Foundations, ed. J. M. Letiche, New York: Academic Press, 1982.

Schmitz, Andrew, Dale Sigurdson and Otto Doering. "Domestic Farm Policy and the Gains from Trade," Amer. J. Agr. Econ. 68(1986):pp. 820-27.

Taff, Steve and C. Ford Runge. Supply Control, Conservation, and Budget Restraint: Conflicting Instruments in the 1985 Farm Bill. University of Minnesota, Dept. of Agr. and Applied Econ., Staff Paper P86-33, 1986.