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Trade Policy and Environmental Quality: The Case of Export Subsidies

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The United States and the European Union both employ export subsidies to stimulate wheat trade and to increase their competitiveness in world markets. The environmental consequences of these policies are being questioned. We stimulate reducing or removing export subsidies for wheat from the United States and the EU using a multicountry partial equilibrium model, and we analyze the impact of export subsidy policy reform on nitrogen fertilizer and other chemical use. Our findings indicate that the U.S. EEP program cannot be blamed for environmental degradation in terms of nitrate leaching, while EU wheat subsidies make only a small contribution to nitrate pollution.

In the early stages of the Uruguay Round (UR) negotiations, the United States and the Cairns Group argued for eliminating all trade-distorting policies in agriculture. Policymakers in the United States made the case for liberalizing agricultural trade based on the gains achieved from free trade and for reducing government budgetary outlays. The Cairns Group, particularly Argentina and Australia, focused their concern on the deleterious trade and competitive effects of export subsidy programs. With the UR agreement achieving only a partial reduction of export subsidies, some agricultural exporting countries continue to be discontent about trade distortions. Additionally, discussions at the Organization of Economic Cooperation and Development (OECD) and the World Trade Organization (WTO) have raised the question of whether trade policies, including export subsidies, are adversely affecting environmental quality. Richard Eglin, the director of the Trade and Environment Division/WTO, has stated that developing an understanding of the linkages between environmental benefits and removing trade restrictions and distortions constitute one of the most important and promising areas of the work program for the Committee on Trade and Environment at the WTO (Eglin 1995).

The literature on the production, trade, and welfare effects of agricultural trade liberalization has become well established over the last decade, but the environmental impact of these reforms is generally neglected. This paper attempts to step into this breach. In this paper we examine the relationship between wheat export subsidy programs and environmental quality, utilizing a multicountry partial equilibrium Armington-type model (Armington 1969). The intensification of chemical applications has been the main stress placed on the environment by farming. Thus, we analyze the impact of this trade policy reform on nitrogen and other chemical use.

Wheat has been chosen since it is the crop that receives the highest export subsidies in the United States and the EU. Most Export Enhancement Program subsidies go to U.S. wheat exports and roughly 60% of all U.S. wheat exports are subsidized by the EEP. Roughly 15% of all EU export subsidies for 1986–91 were devoted to wheat; however, total EU subsidies, as well as the subsidy per metric ton of wheat exported, are much higher than in the United States. At the same time, wheat is the second largest user of fertilizers in the United States, following corn; roughly 14% of all fertilizer in the United States and 22% of all fertilizer in the EU is applied to wheat (Taylor 1994).

Environmental Concerns of Agricultural Production

In the past, agriculture was considered to be a major protector of the environment; nowadays, con-

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flicts between agriculture and the environment are of greater concern. The sustainability of modern production practices is increasingly questioned. Nitrogen fertilizer use is often criticized for having adverse environmental effects (Leuck et al. 1995, pp. 2–5). After application nitrogen breaks down into nitrate, which is needed by plants to aid with photosynthesis.[1] However, plants can absorb only a finite amount of nitrate. The excess can leach into groundwater or run off into surface water.

Public concern for environmental problems associated with nonpoint water pollution and groundwater contamination is growing in Europe because of a very high intensity of agricultural production. Nitrogen use in the United States equals about 22 kilograms per hectare, while it amounts to 75 kilograms per hectare in the EU for all agricultural land, including that which is fallow. In 1991, following the recommendations of the World Health Organization, the EU issued a directive limiting the maximum allowable concentration of nitrate in groundwater to 50 parts per million (the same concentration recommended by the U.S. Environmental Protection Agency). Fertilizers are the largest contributors of nitrogen to agricultural soils, followed by livestock manure. Though not all surplus nitrogen ends up contaminating water supplies, a nitrogen balance provides a measure of potential contamination. A nitrogen balance can be calculated by adding up all nitrogen contributions to the soil (fertilizers and manure) and subtracting the amount that plants will absorb. It is estimated that nitrate levels exceed the EU drinking water standard in 25% of EU agricultural soils (Brouwer et al. 1995). EU surplus nitrogen levels for cereal farms vary from less than 10 to almost 160 kilograms per hectare (ibid., p. 25).

Nitrogen balances for wheat acreage in the United States and the EU are calculated in table 1. The EU fertilizer and manure applications are roughly two to three times as great as those for the United States. Consequently, nitrogen input per hectare in European farms far exceeds input in their American counterparts. EU uptake per hectare also exceeds that of the United States. Nitrogen applications contribute to higher European wheat yields, which, in turn, contribute to higher nitrogen absorption by the plants from the soil. We use data from FAO (1995), the Hague's Agricultural Economics Research Institute (LEI-DLO), and USDA/ERS on fertilizer and manure application rates and uptake coefficients for Europe and the United States to calculate nitrogen balances. Since data for manure applications to all U.S. wheat crops are not available, U.S. manure applications are estimated by extrapolating manure application in the top five producing states to all producing areas.[2] Table 1 suggests the average U.S. nitrogen balance on wheat acreage is roughly 27 kilograms per hectare, compared with nearly 61 for the EU.

Table 1. Nitrogen Balance of Wheat Farms (kilograms of nitrogen per hectare)

	Fertilizer Application	Manure Application	Total Nitrogen Input	Uptake by Wheat	Gross Surplus
United States	74.3	2.1	76.4	49.7	26.7
EU	137.0	6.0	143.0	82.2	60.8

Environmental Quality and Trade Policy

Quantifying the linkages between agricultural trade policies and environmental quality is very complex. (Ribaudo and Shoemaker 1995 address the issue of domestic agricultural policies and chemical use.) Opponents of export subsidies argue that higher prices for agricultural products in the United States and the EU have accelerated the intensification and specialization of agriculture in Europe and the United States, increasing the risks of air, soil, and water pollution as well as of food product contamination (e.g., Schmitz 1987; Kuch and Reichelderfer 1991).

The effects of price support policies are of an indirect nature. The increase in agricultural commodity prices in the EU and the United States has raised the profitability of farm production, thereby inducing farmers to increase production. Since land supply for agricultural production is largely price inelastic, a price-induced increase in the demand for land leads to a considerable increase in the value of land, but little or no supply response.[3] This holds especially for densely populated Europe and leads to two effects, both with potentially neg-

[1] Researchers have linked nitrates to various health hazards (Walton 1951; Mirvish 1991; Bruning-Fann and Kaneene 1993; Morales Suarez-Valera et al. 1993; Weisenburger 1993; Wu et al. 1993; Zandjani et al. 1994).

[2] This procedure likely overestimates manure use, since manure is usually applied close to where it is created, and the top five wheat-producing states are larger livestock producers than are the remainder of the wheat-producing states. These top five states include 65% of all wheat crops and 50% of all wheat production.

[3] We have modeled the supply of land with respect to the specific crop (wheat) as less inelastic than the supply of land with respect to all agriculture. In our simulations described below, the reduction of wheat export subsidies reduces land allocated to wheat by a greater percentage than land allocated to all of agriculture.

ative environmental consequences. First, the increases in land prices induce the introduction into production of marginal land, which may have greater environment sensitivity. Second, given the low supply elasticity of land and the high price elasticity of chemical demand, application of pesticides and fertilizer per hectare rises.

Since export subsidies between agricultural commodities differ, these policies might also lead to a specialization of agricultural production toward those products with relatively high trade protection. From an ecological point of view, this specialization can be damaging if the supported commodity is among the most soil erosive and chemical using. However, trade policies can be environmentally positive if the subsidized product is less polluting and thus shifts resources out of polluting activities.[4] The resource and production effects in the exporting nonsubsidizing countries and the importers also determine the overall environmental impact of trade policies.

The Model

Perceived quality differences among wheat from different exporters suggest that wheat should be modeled as a differentiated nonhomogeneous product. Countries specialize in growing different classes of wheat that vary in protein content, hardness, quality, and cleanliness, among other factors. For example, the United States produces many classes of wheat, most of which are higher quality and contain more protein than EU wheat and are preferable for bread making. Only soft red winter wheat is comparable to the wheat that the EU produces. The Wheat and Inputs Model (WHIM) is developed, assuming each exporter producers its "own" type of wheat, an Armington-type assumption. By following this approach, we can determine how policy changes affect the exporting countries and how the importing countries alter their consumption patterns from specific exporters.

WHIM covers thirty-three regions, seven types of wheat, and six inputs (nitrogen fertilizers, potash and phosphorous fertilizers, pesticides, pasture land, arable land, and labor). WHIM has been parameterized with a 1986–91 average crop-year database. Six main wheat exporters are included in the model: the United States, the EU, Canada, Argentina, Australia, and Saudi Arabia. Since wheat from each country is assumed to be different from that of the other exporters, wheat from each of the six exporters is specified as a separate commodity. Wheat produced in all other countries (including importing countries) is labeled generically as "wheat" (WH).

WHIM has a basic economic structure. It contains supply and demand functions with a constant elasticity form.[5] Supply depends on output and input prices. For each type of wheat producer i and each input j

$$S_i = \alpha_i * PP_i^{V_i} * C_j^{V_j} \tag{1}$$

$$\forall_i \in \text{Producers}, \forall_j \in \text{Inputs}$$

where S is supply, PP is producer price, CP is consumer price, αs are constants reflecting a given technology, and γs are elasticities of product supply and input demand. Demand for wheat from each consuming nation is a function of consumer prices of the various wheats:

$$D_{ki} = \beta_{ki} * CP_{ki}^{\ ki} * CP_{kh}^{\ kh} \tag{2}$$
$$\forall_k \in \text{Consumers}, \forall_i, \forall_h \in \text{Producers}, i \neq h$$

where D is demand, βs are constants, and *ns* are demand elasticities.

The supply of and (derived) demand for inputs also are functions of the relevant input and output prices:

$$S_j = \alpha_j * PP_j^{\mu_j} \quad \forall_j \in \text{Inputs} \tag{3}$$

$$D_j = \beta_j * PP_i^{\nu_i} * CP_j^{\nu_j} \tag{4}$$

$$\forall_j \in \text{Inputs}, \forall_i \in \text{Producers}$$

where μs are supply elasticities and νs are demand elasticities.

Land and labor are assumed to be nontraded so that equilibrium rents and wages are determined within the domestic market. In contrast, other inputs and the various types of wheat are traded implying that equilibrium prices are determined in world markets.

World markets clear when excess supply of a good across all countries is equal to zero. For each main type of wheat, this occurs when:

[4] For a deeper discussion of issues related to trade policies and the environment, see Krissoff 1996.

[5] The constant supply and demand functions were chosen because of their transparent and easy-to-implement form. However, it needs to be mentioned that constant elasticity output supply and input demand functions imply an underlying Cobb-Douglas profit function, which is rather restrictive in nature (see Chambers 1988, 161). For this reason, most of the restrictions implied by a Cobb-Douglas profit function on the elasticity matrix are not imposed. Only symmetry conditions are imposed in this model.

$$S_i - \sum_k D_{ki} = 0. \quad (6)$$

For generic wheat and traded inputs, this occurs when:

$$\sum_i S_i - \sum_i D_i = 0 \quad (7)$$

$$\sum_j S_j - \sum_j D_j = 0. \quad (8)$$

The domestic price equals world price (*WP*) adjusted for subsidies (Ψ), transportation costs (C), and the exchange rate (E):

$$PP_i = C_i E_i WP_i (1 + \Psi_i) \quad (9)$$

and

$$CP_k = C_k E_k WP_k (1 + \Psi_k). \quad (10)$$

We model the EEP subsidies and EU restitution payments as consumer subsidies; that is, they enter into importing nations' consumer price formulas for U.S. and EU wheat, respectively. When the subsidies are reduced, consuming nations face a higher price for the respective wheat, thus reducing quantity demanded and raising world price. The new higher world price is then fed back through each country's domestic prices until supplies and demands adjust, and equilibrium prices and quantities are restored.

Note that WHIM is purely a wheat model; there are no substitute crops or livestock sectors, so that the model cannot determine what happens to wheat area taken out of production. Our nitrogen balance calculations therefore should be interpreted as changes in nitrogen balances with respect to changes in (wheat) export subsidies, other things being equal, namely, other commodity market conditions held constant.

In the United States, it is likely that corn, a highly intensive input user, could be planted in the corn belt and on irrigated land. However, much land that grows wheat is unsuitable for corn, either being too dry or otherwise having the wrong climate. In the northern plains, barley and sunseed, less intensive nitrogen users than wheat (Tobey 1991), are likely substitutes. In the west, sorghum is the most appropriate substitute, and in the south, possibly cotton; both sorghum and cotton use more nitrogen per hectare than does wheat. Most U.S. wheat is produced in the "wheat belt," where wheat is the primary crop. Thus, the majority of excess nitrogen in "wheat belt" soil can be attributed to fertilizer application from wheat production.

Substitute crops in the EU are similar to those in the United States. Corn is a possible substitute on irrigated land and in warmer climates. The major substitute crops for the remainder of European land would likely be barley, rapeseed, and sunseed, less intensive users of nitrogen. Unlike the United States, the EU does not practice monocropping. European farmers rotate their crops and often grow a variety of crops on their acreage each crop year. Thus, it is more difficult to determine what proportion of EU nitrate pollution could be directly attributed to wheat.

Because these crops vary in the structure and level of input usage, and because the model does not include substitution possibilities, there are no assumptions about crops grown on land taken out of wheat production and possible nitrogen applications. Instead, when land is taken out of wheat production, we exclude it from our nitrogen balance calculations, this procedure may have the effect of understating nitrogen balances in a region, and thereby overestimating the positive environmental effect. Modeling the substitution effects of other commodities should be the subject of further research.

Data

The average of the 1986–91 crop years is selected as the base. The data source for wheat supply, trade flows, and export prices is the International Wheat Council (IWC 1992). Information with respect to transport costs and subsidy data for the United States and the EU are also taken from the IWC, while the remainder of the transport data are obtained from Maritime Research Inc. The USDA is the source of U.S. wheat class trade flow data, EEP subsidies, and PL-480 wheat sales and donations.

The average EEP subsidy offered by the United States to each of the targeted importers is modeled as a consumer subsidy for the importing country. Each EEP recipient receives a unique level of subsidy. An EU export restitution of \$80 per metric ton is used as an approximate mean between the high (\$134 per metric ton) and the low (\$42.4 per metric ton) average restitution. Each EU restitution recipient receives the same level of subsidy and therefore faces similar prices.

For the EU and the United States six inputs are modeled: nitrogenous fertilizers, potassium and potash fertilizers, pesticides, pasture land, arable land, and labor. Since detailed input data are not easily or consistently available for each of the other countries, we assumed a rest-of-world group-ing to include all other countries' inputs. Consumption and trade data for inputs are from OECD and FAO, respectively. Production is the difference between consumption and net trade.

Nitrogen balances are calculated exogenously utilizing the information in table 2. Because we assume livestock levels (and therefore manure use) to remain constant, changes in our nitrogen balances are attributed to changes in fertilizer application and yields. We assume that the rate of nitrogen uptake by wheat (in kilograms of nitrogen per metric ton of wheat) does not change. Also, we assume a fixed level of production for other crops. We estimate yields by dividing wheat production by land use.

Elasticity values used for this study come from numerous sources. Generic wheat supply and demand elasticities were taken from the ERS SWOPSIM Global Database (Sullivan et al. 1992). The values of the remaining wheat elasticities are based on information from Haley, Leetmaa, and Webb (1993). These elasticities are based on a function of a country's end uses for the wheat. The elasticities also reflect the preferences of, and the constraints face by, those who make wheat import decisions. The values of the inferred between-class elasticities tend to be low (0.50), and the between-supplier elasticities tend to be higher (3.0). For more information on elasticities see Haley, Leetmaa, and Webb 1993.

Own price and cross price elasticities with respect to the inputs were obtained from various sources including Ball (1989), Hertel (1994), Denbaly and Vroomen (1991), and Boyle and O'Neill (1990). The cross price elasticities between output supply and input demand, as well as among input demands, were defined by imposing symmetry conditions.[6]

[6] Complete elasticity matrices are available from the authors (in either hard or electronic copy) upon request.

Simulations and Results

We consider three scenarios: (1) removal of both U.S. and EU export subsidies for wheat; (2) removal of the EEP alone; and (3) a partial reduction in both the EEP and EU export restitutions. The scenarios demonstrate the effect of export subsidies on wheat production, consumption, trade, chemical and land use, and nitrogen balances. The export subsidy eliminations/reductions in scenarios 1 and 3 demonstrate the combined effect that the U.S. and EU export subsidies have on agriculture and environmental quality. For the EU, export subsidies account for the major government intervention in the wheat market. For the United States, other government programs are significant (deficiency payments, for example) and are assumed not to change. Thus, our scenarios address the issue of export subsidies—trade policies—and their influence on environmental quality, but do not consider the effects of all government intervention in the wheat market.

Scenario 2, the U.S. unilateral policy reform, stems from concern about the EEP's budgetary exposure and its environmental consequences. The EEP has cost U.S. taxpayers nearly $1 billion per year from 1991 to 1994. Scenario 3 reflects multilateral reform; in the Uruguay Round of the GATT, contracting parties agreed to cut export subsidies. The export subsidy reductions necessary for the United States and the EU to meet GATT requirements are stimulated in this experiment. By simulating the changes in wheat production and input use for the United States and the EU, we can estimate changes in the nitrogen balances of both regions for each of the scenarios.

Pesticides are only briefly discussed in this paper because wheat is the least pesticide-intensive major field crop. In 1990, wheat accounted for roughly 29% of total U.S. acreage but only 3% of pesticide use. Nearly 45% of all wheat receives no

Table 2. Changes in Production, Input Use, and Gross Nitrogen Balance per Wheat

	Total Removal of U.S. and EU Export Subsidies		Removal of the EEP		Bilateral Reductions in U.S. and EU Export Subsidies	
	United States	EU	United States	EU	United States	EU
Wheat exports	+0.6%	−55.5%	−9.2%	+3.4%	+3.5%	−46.0%
Wheat production	+0.8%	−8.7%	−3.6%	+0.6%	+1.9%	−9.6%
Demand for NF	+0.2%	−2.4%	−0.9%	+0.2%	+0.5%	−2.8%
Demand for PF	+0.2%	−1.9%	−0.6%	+0.1%	+0.3%	−2.5%
NF use on wheat	+1.4%	−10.1%	−5.6%	+7.0%	+2.8%	−11.9%
PF use on wheat	+1.7%	−8.8%	−5.8%	+5.9%	+2.9%	−11.6%
N balance, gross	+0.7%	−4.0%	−1.8%	+0.4%	+0.6%	−6.2%

NF = nitrogen fertilizer; PF = phosphate and potash fertilizer; N = nitrogen.

pesticides. In contrast, corn is the most intensive pesticide user among the grain field crops and accounts for the largest acreage. In 1990, just over 45% of all U.S. pesticide applications were made to corn (USDA 1994). Thus, in the future it might be desirable to extend the analysis to corn or other pesticide-intensive crops and to discuss the effects on pesticide use in more detail.

Removal of U.S. and EU Export Subsidies

In our first simulated experiment, we remove all U.S. and EU export subsidies for wheat. Without export subsidies, importers face higher prices in world markets. Because EU export subsidies are much higher than U.S. subsidies, their elimination forces the relative price of EU wheat compared with U.S. wheat to increase. Foreign consumers purchase considerably less EU wheat, while the demand for U.S. wheat increases slightly. Total exports of U.S. wheat increase by less than 1%, while exports of EU wheat fall by approximately 55% (see table 2). The excess supply of wheat in the EU places downward pressure on domestic wheat prices, generating a decline in EU wheat production and wheat acreage.

As EU farmers decrease their production of wheat, land is withdrawn from wheat production. Typically, this raises average yields (and uptake of nitrogen) because less efficient land is the first to be taken out of production. The reduction in land devoted to wheat and the utilization of more fertile land leads to a decline in total chemical use for this crop. Profitability of fertilizer and pesticide application declines because of the fall in the wheat prices. Overall, the fall in total fertilizer (and pesticide) demand is moderate, but in terms of fertilizer use per hectare of wheat grown, the declines are more significant (see table 2). Nitrogen, phosphate, and potash fertilizer use decline by 9 to 10%. Furthermore, there is a 4% decrease in excess nitrogen balances on wheat land, with a potential positive impact on the environment.

Removing subsidies has a greater impact on nitrogen balances in the EU than in the United States for two reasons. Unlike in the United States, in the EU the internal wheat price is higher than world wheat prices, requiring large export subsidies per unit for all wheat trade. The removal of subsidies limits EU trade and production, inducing an increase in world market prices for wheat. The world market price rise more than the offsets the decline in U.S. prices because of the elimination of U.S. export subsidies, thereby making U.S. wheat even more competitive in world markets and increasing production. As a result, U.S. wheat production expands. Wheat acreage increases and more nitrogen fertilizer per hectare is applied, resulting in nearly a 1% increase in the U.S. nitrogen balance. Since nitrogen balances decline about 2.5 kilograms per hectare in the EU relative to a marginal increase in the United States, the elimination of subsidies provides small improvement in overall environmental quality.

Unilateral Removal of the EEP

To reduce the U.S. government budget deficit, some policymakers have suggested eliminating the EEP. To assess how this affects U.S. wheat exports and input use, we simulated a unilateral removal of the EEP. Unlike the results of the bilateral liberalization, those of the unilateral liberalization indicate a decrease in demand for U.S. wheat exports and thus in U.S. competitiveness. U.S. wheat exports decline by approximately 3 million metric tons, or nearly a 9% decline in export volume (table 2).[7]

The reduction in U.S. wheat production results in weakened demand for both fertilizer and pesticides (see table 2). Nitrogenous and phosphate/potash fertilizers decrease by roughly 1%, which translates into approximately a 6% fall in fertilizer applications to wheat. Because the average fertilizer application per hectare decreases, the average U.S. nitrogen balances decline by nearly 2% to 26.2 kilograms per hectare. This is clearly a very small reduction.

The net environmental effect on the United States could be negative if more land is allocated to corn or other chemical-intensive crops. Additionally, the results in table 2 reveal that the elimination of wheat export subsidies in the United States will be marginally detrimental to the EU environment. As U.S. wheat production decreases, global wheat prices increase, expanding wheat production and nitrogen fertilizer application in the EU. The increase in production augments the average rate of nitrogen uptake by EU wheat, partially offsetting the increase in nitrogen fertilizer application. Thus, nitrogen balances increase only slightly.

Bilateral Liberalization

The likelihood for all U.S. and EU export subsidies to be eliminated is remote. However, both

[7] Previous studies have analyzed the EEP in terms of additionality, which is defined here as the increase in U.S. exports that occurred because of the EEP. For 1985–86, Hillberg (1988) found the additionality attributable to the EEP to be between 2 and 3%. Later studies by Bailey (1988, 1989), Seitzinger and Parlberg (1989), and Brooks, Devadoss, and Meyers (1990) found additionality to range from 7 to 20%.

countries have agreed in the Uruguay Round (UR) agreement of the GATT to decrease subsidized exports by 21% in volume and 36% in value by the year 2000. In our third scenario we replicate a GATT-like reduction in export subsidy programs.[8] We assume that the United States decreases the value of subsidized exports to all countries by 36% and that the EU's 1992 CAP reform meets the goals set in the Uruguay Round. The EU CAP reform reduced internal grain prices by an average of 30% and also introduced a set-aside program (similar to the U.S. acreage reduction program) whereby farmers are required to set aside 15% of their land grown with grain and oilseeds to receive the compensatory payments. Farmers harvesting less than 92 metric tons of grain per year are exempted from the set-aside obligation. To capture these policy changes, we reduce EU expert subsidies per unit by 30% and we assume a 10% reduction in arable land (set-aside) to account for the small-farm exemption.

The simulation results indicate that U.S. wheat producers benefit from the GATT and CAP reform (table 2). U.S. wheat production and exports increase slightly, resulting in a marginal increase in the nitrogen balance. However, the EU has to bear a loss in competitiveness on the world wheat market and experiences a reduction in its excess nitrogen balances. The mandatory set-aside encourages farmers to remove their least productive land from production, increasing yields (ceteris paribus) and the uptake of nitrogen by wheat in kilograms per hectare. The reduction in EU prices causes a fall in production. The decline in EU wheat production puts downward pressure on fertilizer demand, which—coupled with the increase in nitrogen uptake—causes excess nitrogen balances to decrease.

Conclusion

In this study our interest focuses on quantifying the indirect relationship between wheat export subsidies and environmental quality. Decreases in export subsidy programs reduce domestic prices and discourage production. In turn, the fall in production decreases the need for both chemical resources (in particular, nitrogen fertilizer) and land resources, which may improve environmental quality. We use nitrogen balance as a proxy measure for environmental quality because surplus nitrogen may end up contaminating ground and surface water supplies by leaching or through runoff.

Our findings indicate that the quantitative impact of U.S. and EU export subsidies for wheat are modest. The U.S. EEP program cannot be blamed for significant environmental deterioration in terms of nitrate leaching on wheat acreage. In contrast, EU wheat subsidies do contribute to nitrate pollution, but these environmental effects are not large.

Though our analysis suggests that there is little relationship between wheat export subsidies and nitrogen balances, our methodology may suffer from using an aggregate approach, that is, we estimate a national average nitrogen balance. Were we to analyze nitrogen balances on a regional or farm level, the results could differ. By using the national average nitrogen balance, all reductions or increases in fertilizer use are averaged over the entire country (or group of countries). If we assume that the reduction in fertilizer applications occurs in only the most fertilizer-intensive regions, there could be a much larger decrease in nitrogen balances within such a region, suggesting that export subsidies may have more of an effect on the environmental quality. In this way, a more likely upper bound estimate could be ascertained.

For example, according to Brouwer et al. (1995), the highest nitrogen balances for grain farms occur on roughly 25% of farms in Germany and France (115 and 126 kilograms per hectare, respectively). If we assume that the entire EU reduction in EU fertilizer use from eliminating export subsidies occurs only in Germany and France, and that all of the wheat farms in Germany and France have balances of 115 and 126 kilograms per hectare (which they do not), we can calculate the effect on the areas most susceptible to high nitrogen balances. Using these assumptions, we estimate the change in the nitrogen balances to be approximately 8%, almost double the effect on the EU as a whole relative to our original analysis. Thus, there may be a strong relationship between export subsidies and nitrogen balances than we indicate above, though it is unlikely that it would be as strong as estimated in our German and French example.

There are several additional imitations to this research. First, we consider the effect of export subsidies only on wheat and its relationship to environmental quality. We do not analyze the environmental consequences of resource allocation to alternative uses in the production of other agricultural or nonagricultural commodities. Further, we do not consider the environmental effects of reduc-

[8] Our simulation is GATT-like since it assumes the year 2000 looks like the 1986–91 average. Also, we do not project new base levels by assuming any productivity increases, population growth, or income growth. Additionally, we assumed no relaxation of U.S. set-aside policies. If we had assumed relaxation, it is likely that U.S. wheat production and exports would have increased.

ing other trade or domestic agricultural policies for other crops and livestock products. Capturing the production, consumption, and trade effects of a broader liberalization in a general equilibrium framework is important in discerning the reallocation of resources and its impact on environmental quality. Second, we focus our attention on nitrogen balances, only one indicator of environmental quality. We do not consider soil erosion or any other potential environmental deterioration.

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