Environmental and Economic Implications of Alternative EC Policies

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Abstract

A net trade model that includes environmental variables is used to analyze economic and environmental implications of various EC policies. There are environmental benefits from CAP reform, but a fertilizer tax results in greater nitrate and phosphate abatement. The input tax also results in smaller drops in EC farm income compared to CAP reform.

Key Words: CAP reform, environmental policies, European Community, fertilizer tax, net trade model, Nitrate Directive

Pollution from agricultural production is of growing concern in the EC, US, and other developed countries. It is increasingly recognized that price supports provided to farmers in major developed countries and other forms of support have encouraged expansion of output using production methods which are intensive in the use of potentially polluting inputs such as fertilizers, pesticides and fossil fuels. Furthermore, high support to agriculture has resulted in increased livestock production which has increased waste material such as pig and poultry manure.

A major environmental concern in the EC is the effects of chemical fertilizers and animal manure on water quality. Eutrophication of inland and coastal waters caused primarily from nitrogen and phosphate run-off is a serious and widespread problem in the EC. High levels of algae, caused primarily by phosphate run-off, reduce available oxygen in water and thus can kill fish and other aquatic life. Many minor rivers in northwestern Europe are dying largely due to contamination from agriculture. Nitrate leaching into groundwater has also seriously damaged drinking water quality in many intensively farmed areas. Largely due to agricultural effluent, it is estimated that five to six percent of EC population is being supplied with drinking water that contains more nitrates than the permitted EC maximum of 50 mg/l (Agra Europe). The problem seems to be worsening. In 1979, 126 local water authorities in West Germany were tapping sources which exceeded the maximum permissible level for nitrates. In 1983, the number of tappings that exceeded the maximum permissible level had risen to 807 (Field).

Increased levels of nitrates in drinking water is a health hazard, especially for babies under the age of six months. Nitrates, which are produced in the body from nitrate reacts with hemoglobin to reduce its capacity to carry oxygen in the blood stream. This disorder, methemoglobinemia, often called "blue baby" disease, most often strikes infants under six months.

A major culprit of this environmental contamination is agriculture. Chemical fertilizer use in EC countries is among the highest in the world. In 1989, 16 percent of world's fertilizer was consumed in the EC. The intensity of fertilizer use in the EC is illustrated by the fact that North America, with a much larger agricultural land base, consumed less fertilizer than the EC. An additional

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source of nitrogen and phosphorus delivery to the soil is livestock effluent. Effluent from intensive livestock production is now taking over from the chemical industry as the major source of river and groundwater pollution (Agra Europe).

Because of these concerns, the EC is investigating options to reduce nitrate and phosphate use and thus lessen their deliveries to the ecosystem. Among the options discussed is a tax on fertilizer consumption and restrictions on effluent production from animals. The EC is currently in the process of implementing the Nitrate Directive, which places limits on the amount of manure produced per unit of land. In addition, although reform of the Common Agricultural Policy (CAP) is undertaken primarily for non-environmental concerns, changes in output and input use will have environmental consequences.

The purpose of this paper is to examine the economic and environmental consequences of several EC policies. Since the EC is a large trader of agricultural commodities, the analysis is undertaken in an open economy framework using a net trade model. One of the questions this paper addresses is to what extent will CAP reform affect EC environmental objectives, particularly reduction of nitrate and phosphate pollution from fertilizer and animal manure? How does CAP reform compare to a specific environmental policy-- a fertilizer tax-- regarding the effect on production, environmental degradation, input use, world prices and trade? The empirical results illustrate the different outcomes between policies aimed at changing input use indirectly through changes in output (CAP reform) and those policies aimed toward changing input use directly such as the fertilizer tax.

Hanley is among the few studies to examine the implications of EC environmental policies. But the focus has been on domestic effects, thus, the study has little to say about international consequences for agriculture. Gunasekera, Rodriguez, and Andrews (GRA) examined the domestic and international implications of an EC fertilizer tax, but their model does not include inputs and they have little to say about the environmental impacts of CAP reform, nor can they assess the effects of policy changes on fertilizer use. Many more studies have considered the effects of international agricultural policy reform. Examples include Roningen and Dixit, Tyers and Anderson, Parikh et al., OECD, but these studies, because they do not include inputs, have nothing to say about input utilization and environmental consequences. Anderson, is among the first to examine the environmental consequences of policy reform. He does an excellent job in presenting the issues, but his model does not contain inputs, hence, empirical assessments of policy reform on the environment are inferred from changes in output and from evidence outside his model. More recent analyses have overcome some of the deficiencies of earlier work by including inputs. Abler and Shortle (1992a, 1992b) develop a model that includes an aggregate chemical input, but fertilizer use is not explicitly modeled, therefore effects of policies on nitrate and phosphate pollution can not be determined from their model. Furthermore, their policy scenarios do not include a fertilizer tax nor do they analyze the impacts of the Nitrate Directive. Haley examines many of the scenarios described here, but his model only includes one input, nitrogenous fertilizer.

The Model

The model utilizes the Static World Policy Simulation Model (SWOPSIM) modeling framework (Roningen). The version of the model used for this analysis is a modification of ST86, the model used by Roningen and Dixit to assess effects of trade liberalization. It is a static, partial equilibrium net trade model representing 1986/87 world agricultural conditions. It divides the world into 11 countries/regions and it contains 22 commodities. ST86 was modified by changing the production structure for the US and the EC. Dairy products (butter, cheese, and milk powder) along with oilseed products (meal and oil) are omitted because they are not produced on the farm. Since ST86 does not model all agriculture, an aggregate 'all other commodities' (farm produced commodities not included in ST86) was added to the model. The other output commodities in the model are: beef and veal, pork, mutton and lamb, poultry meat, poultry eggs, milk, wheat, corn, other coarse grains (barley, rye, oats, etc.), rice, soybeans, other oilseeds, cotton, sugar, and tobacco. Seven inputs are included in the model: durable equipment, real estate, farm purchased durables, hired labor, energy, fertilizer, and 'other purchased inputs', an aggregate of pesticides, seed, pharmaceutical etc. Inputs, except for real estate, are perfectly mobile within each country, but perfectly immobile between countries.

In contrast to the supply elasticity parameters in ST86 which are derived from a variety of sources using single-crop, single-equation specification, the output-supply and input- demand elasticities for this model were derived based on the multiple output specification of production. By exploiting developments in duality theory and flexible functional forms, parameter estimates from an econometrically estimated multiple-output multiple-input profit function of U.S. agriculture (Ball) were disagregated to generate parameters for this model. These parameters are based upon profit maximizing behavior and they fulfill symmetry and homogeneity constraints (Liapis). Input demand and output supply elasticities for the EC were generated using the same methodology. However, because information is sparse for the EC, input-demand and output-supply elasticities were obtained by utilizing EC shares and by assuming that EC agricultural production technology is the same as US technology. The structure of the other countries or regions were not altered from the original ST86 specification.

A criticism of the SWOPSIM modeling framework, and other partial equilibrium models, is that linkages among sectors are missing. Nevertheless, such models are used often as indicated by the references cited above. An advantage of the SWOPSIM framework is that it is rich in policy, country, and commodity detail. Since the policy changes analyzed are commodity specific, a partial equilibrium model, with sufficient commodity detail, captures most of the important relationships. This model is more general than most partial equilibrium models because it includes factors of production in a comprehensive way. In addition, the model includes an agronomic component which generates information for the environmental load variable. By including inputs and the environmental load variable in the analysis, understanding of the environmental consequences, resulting from various policy changes, is enhanced.

One of our primary goals is to determine how the various EC policies affect agriculture's delivery of nitrates and phosphates to the ecosystem in order to get an assessment of environmental effects. A nutrient balance component that tracks nutrient delivery-to and withdrawal-from the ecosystem, is added to the US and the EC models.

Average chemical content (nitrogen, phosphorus, potassium) of manure by type of animals were obtained from Koopmans. These coefficients, along with chemical fertilizer consumption, were used to generate gross nutrient delivery in the EC. Koopmans also provided coefficients for nutrient retention by the various crops. Similar information for the US was obtained from USDA and the Fertilizer Institute. Changes in gross delivery of nutrients are calculated by adding the changes in fertilizer demand to changes in livestock production. Net delivery is calculated by subtracting the nutrient content implied in the crops produced from gross deliveries. Net nutrient deliveries is our indicator variable for the potential environmental consequences of various policies.

There are limitations to the use of these coefficients to calculate nutrient delivery. For example, the EC coefficients are for a specific EC country while we apply them to the entire EC. In addition, the fate of the nutrients in the environment (rate of leaching or run-off for example) depends upon many factors including soil type, slope, and weather, as well as crops grown. These limitations imply that less significance should be placed on the total nutrient level and more significance attached to changes in nutrient deliveries resulting from the various policies. Furthermore, we cannot quantify changes in nutrient balances to actual improvements in water quality or other environmental criteria. However, net change in nutrient delivery to the soil serves as a useful indicator of potential environmental effects of various EC policies.

Scenarios Examined

Five scenarios, simulating different policy options are examined to determine their effect on production, prices and the environment; 1) fertilizer tax (fert tax), 2) Nitrate Directive (nitr dir), 3) CAP reform (macs), 4) CAP reform and the Nitrate Directive (macs&nitr), and 5) fertilizer tax and the Nitrate Directive (fert & nitr).

The fertilizer tax scenario assumes that the EC imposes a 50 percent ad valorem fertilizer tax. The objective of this policy is to reduce chemical fertilizer use. The 50 percent rate is arbitrary. It is not an optimum 'piguvian' tax that equilibrate marginal social costs with marginal social benefits. This rate is examined because conventional wisdom holds that a fairly high tax rate is needed in order to affect producer behavior in the EC. Furthermore, a 50 percent tax rate was examined by GRA, and it would be interesting to compare their results with those from this model.

The second scenario examined is the EC Nitrate Directive. Its objective is to reduce production of animal effluent. The thrust of the Directive is to place limits on livestock density per unit of land. Although many of the provisions have yet to be worked out, preliminary indications are that the Directive will lead to the following percentage changes in EC livestock supplies: beef -4.8 percent; dairy -7.8 percent; pork -11.7 percent; poultry -10.1 percent; mutton/lamb -0.91 percent (Leuck). The EC will implement the Directive within the context of CAP reform. Little will be said about the economic effects of the Directive as a stand alone policy. Results are presented to illustrate the environmental effects of the policy.

The third scenario examined is CAP reform, often referred to as the MacSharry Plan. There have been many versions of CAP reform. The one examined here includes a 35 percent cut in producer price of grains (excluding rice); a 15 percent cut in the producer price of beef; a 5 percent cut in butter price which for this model is translated into a 3 percent cut in the producer price of dairy; and a 15 percent set-aside rate for grain, oilseed, and protein crop area. The effective set-aside rate is less than 15 percent, however because small farmers do not have to participate in the set-aside program. The effective set-aside rate is further reduced for this model because it includes all agricultural area, not just area devoted to grain and oilseed production. Hence, the effective set-aside rate is 3.4 percent of total utilized agricultural area.

In order to compensate growers for the price cuts and for the set-aside program, the EC provides compensation payments to grain and oilseed producers. There is a question as to whether these payments are decoupled from production. For this analysis, we assume that the payments are two-thirds decoupled.

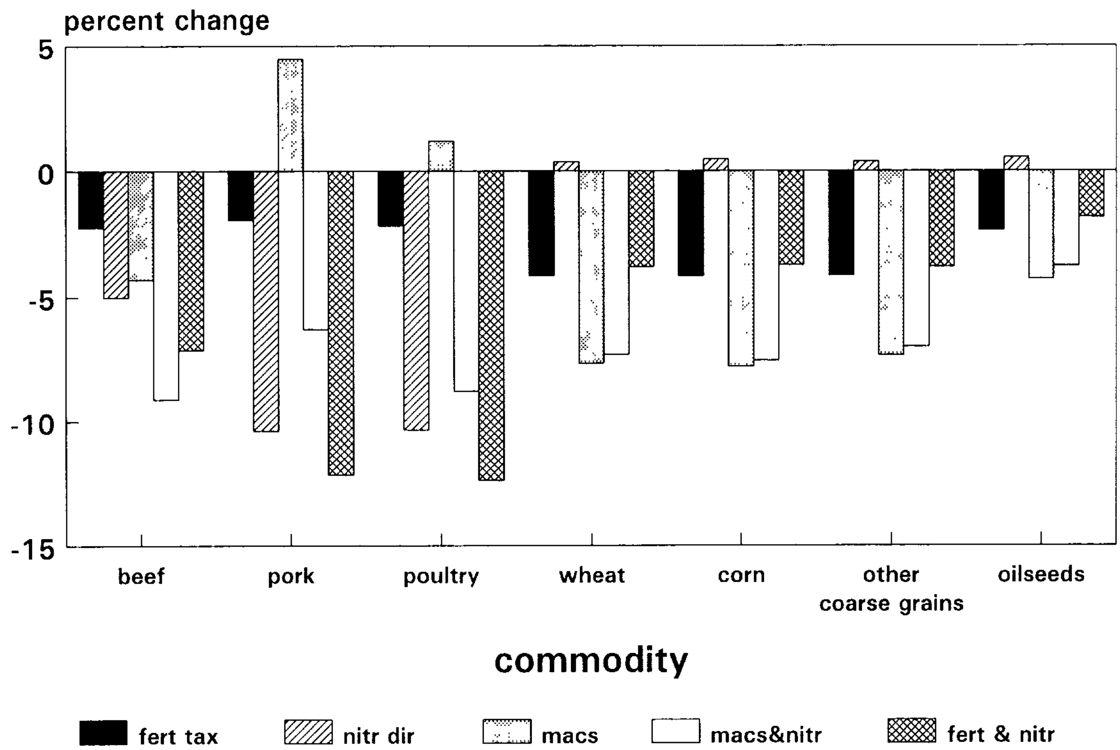
Results

The effects of the various EC policies on domestic production of selected commodities are shown in figure 1. Each policy has a differential impact on the production of each output. As expected, imposing the fertilizer tax leads to a relatively large drop in crop supplies compared to the supply of livestock products. The Nitrate Directive on the other hand, has the opposite effect--livestock supplies decline relatively more, whereas crop production is marginally affected. CAP reform leads to an expansion in the supply of pork and poultry because producer prices for these two commodities are not mandated to fall whereas the producer price of beef is mandated to fall. The large price declines for grains mandated by CAP reform lead to relatively large drop in crop supplies. In the two scenarios that examine the effects of implementing two policy instruments, the output changes are larger relative to the scenarios where only one policy change was imposed. When the Nitrate Directive is imposed on top of CAP reform, production of pork and poultry falls because the supply restrictions mandated by the Directive outweigh the price effects of CAP reform.

The changes in output due to the various policy changes, lead to a fall in receipts from marketings. Gross receipts (excluding direct payments) fall the most under the CAP reform and Nitrate Directive (macs&nitr) scenario with an 11 percent drop, while receipts decline the least (2.6 percent) under the fertilizer tax scenario. Imposing the fertilizer tax and the Nitrate Directive leads to a 5.7 percent drop in gross receipts from marketings, while CAP reform results in an 8 percent drop.

The effects of the various policies on input utilization are shown in figure 2. As expected, reductions in output associated with these policies lead to a reduction in input use. Each policy affects the utilization of each input differently because of changes in relative output prices. Demand for durable equipment changes marginally regardless of the policy, whereas the fertilizer tax leads to a large (20 percent) decline in fertilizer demand while also leading to small declines in the utilization of the other inputs. CAP reform has the largest impact on the demand for inputs other than fertilizer in contrast to the Nitrate Directive which has a negligible effect on input use.

Figure 1. Changes in EC production of selected commodities due to various EC policies.



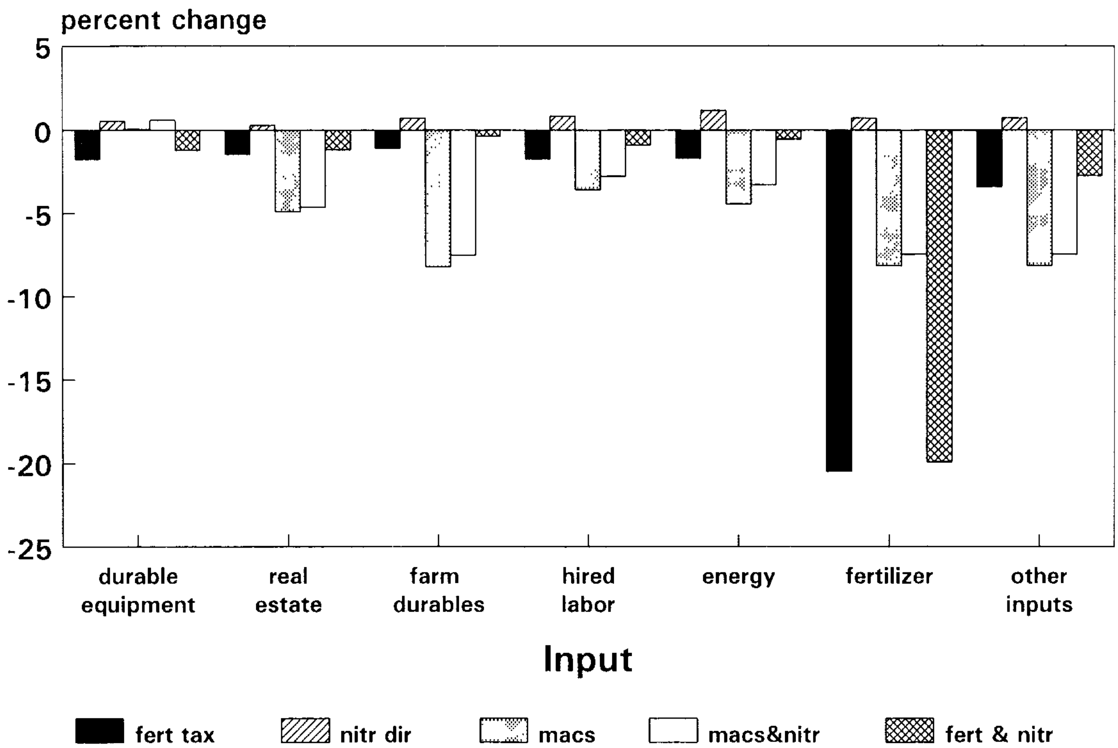
The various policies also lead to lower rental rates. Land rents decline the most with CAP reform (-7.6 percent). Lower output and input use reduces the demand for land and lowers rents. Land rents with CAP reform would be even lower, were it not for the set aside requirements. By reducing land supply, set aside leads to higher land rents *ceteris paribus*. The 50 percent fertilizer tax also leads to lower land rents (-7.1 percent). This result is contrary to conventional wisdom which holds that land and fertilizer are substitutes. The technology that undergirds the model conforms with Sakai's characterization of a normal technology in the long-run and inputs are complements.

As one would suspect, farm income falls following implementation of these policies. The fertilizer tax results in the smallest drop in farm income (-7.3 percent), whereas the combination of CAP reform and Nitrate Directive leads to the largest drop (-26.1 percent). If CAP reform is implemented without the Nitrate Directive, farm income falls 13.4 percent.

What are the environmental consequences of these policies? Information on input utilization improves somewhat our ability to assess the environmental consequences of the policies. Assuming less of a potentially polluting input such as fertilizer, energy or pesticides is preferred to more, we can rank policies based on which one reduces the offending input the most. Note that policies that reduce output the most may not necessarily be the same policies that reduce use of offending inputs the most. For example, CAP reform results in larger output declines compared to the fertilizer tax, but the fertilizer tax leads to greater reductions in the use of a potentially polluting input, fertilizer.

Our ability to assess the potential environmental consequences of the various policies is further improved by the inclusion of the agronomic component which tracks the delivery of nutrients to the soil. Figure 3 shows the net delivery of nitrogen, phosphorus, and potassium, to the soil, as a result of the various policies, based on

Figure 2. Changes in resource use in the EC due to various EC policies.

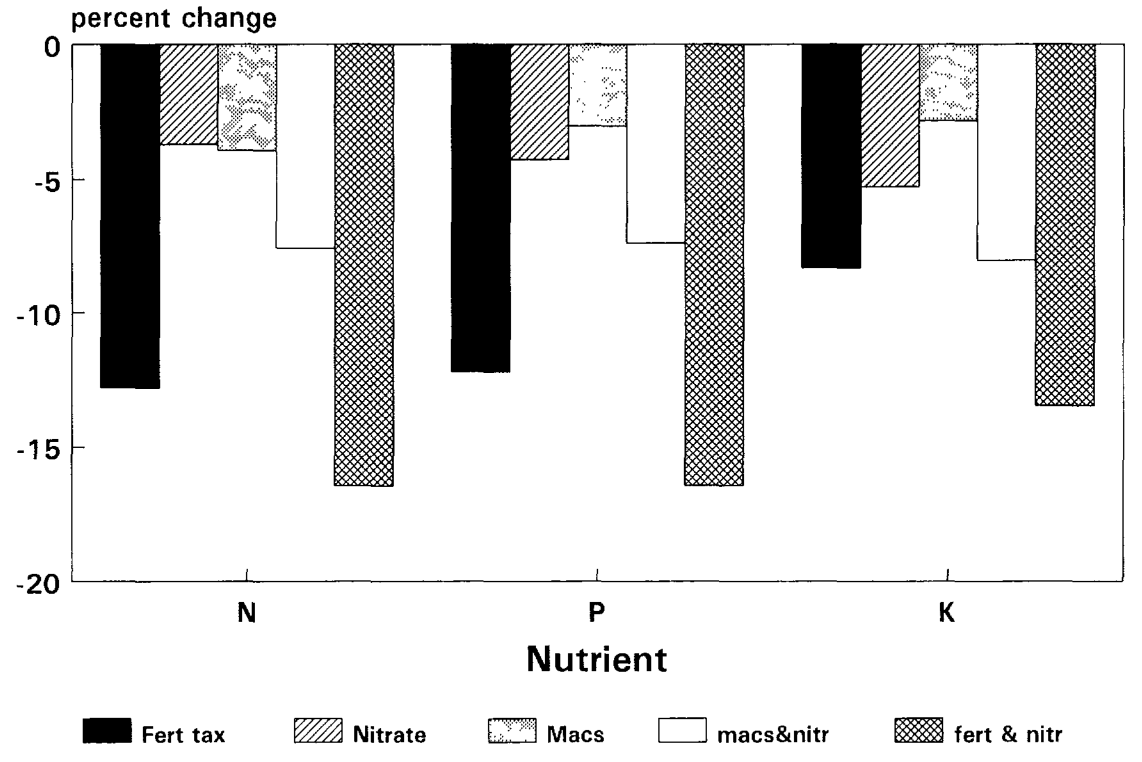


the coefficients described earlier. Changes in livestock production and changes in fertilizer demand resulting from policy changes, also causes changes in the amount of nutrients delivered to the soil. However, not all of the nutrients remain in the soil to potentially pollute. Crops utilize a portion of these nutrients. Changes in crop production leads to changes in nutrient uptake which is subtracted from gross deliveries to obtain net deliveries. Although it is not possible to relate changes in net delivery to changes in water quality (surface or groundwater), net changes in nutrient deliveries is our indicator variable for potential environmental load.

Results in figure 3 illustrate that reductions in input use do not translate into a one for one reduction in net nutrient delivery. Although the fertilizer tax scenario leads to a 20 percent reduction in fertilizer use, nitrogen delivered to soil declines only 13 percent whereas phosphorus delivery declines only 12 percent. The results further suggest that the Nitrate Directive leads to relatively small decline in net nutrient delivery, mostly because the demand for chemical fertilizer is little affected by this policy.

One of the interesting and surprising results is the relatively small impact of CAP reform on the reduction of nutrients delivered to the soil. The delivery of nitrogen and phosphorus, the two main contributors to water pollution, decline less than 5 percent. Nutrient delivery under CAP reform declines less than under the fertilizer tax scenario even when the Nitrate Directive is combined with CAP reform. This result illustrates that when the policy objective is to reduce use of an environmentally damaging input, policies that are primarily aimed toward changing output decisions are not as effective as policies aimed toward changing input decisions. That is, first best policies are those that internalize the externality. Given the EC's objective of reducing nitrogen and phosphorus load, a fertilizer tax is more effective than the Nitrate Directive.

Figure 3. Changes in nutrient balance of EC agriculture due to various policies.

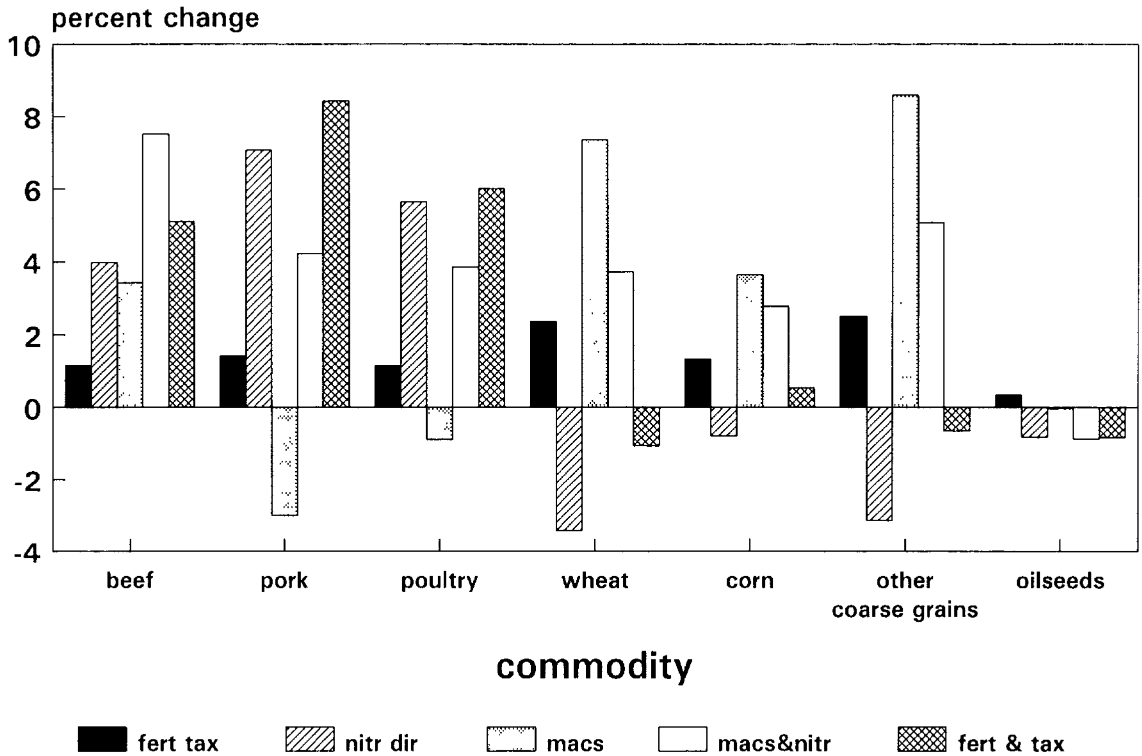


The results further demonstrate that there are environmental benefits associated with CAP reform. By reducing distortions in EC output prices, resources, including potentially polluting inputs such as fertilizers, are released from the agricultural sector. These social benefits should be included when assessing the cost and benefits of reforming the CAP. The results also indicate however, that if the objective is to reduce nitrogen and phosphorus deliveries to the environment, direct instruments, such as the fertilizer tax, are more efficient than CAP reform. The results presented here illustrate that the policy which internalize the externality not only generates greater social benefits, (as measured by nutrient load in the environment), it also leads to smaller private costs. Taxing fertilizer not only leads to greater reductions in nutrient delivered to the soil, it also leads to smaller drops in farm income compared to the other policies examined.

Although the policies examined are domestic, they affect world prices and hence potentially impact on the environmental quality of other countries. The world price effects of the various policy scenarios examined are shown in figure 4. As the figure illustrates, policy changes in the EC can lead to substantial increases in world price of most commodities (except for oilseeds which are not produced in great quantities in the EC).

The results indicate that the net effect of the EC policies is to increase the world price of the various commodities. The exceptions are pork and poultry prices with CAP reform and grain prices with the Nitrate Directive. World price of pork and poultry decline slightly under CAP reform because supplies in the EC expand. (The reader is reminded that CAP reform mandates price cuts for beef but not for pork or poultry). As a result exports of these products increase which depresses world prices. World prices of grains (wheat, corn, and other coarse grains) decline with the Nitrate Directive. This is mostly demand induced. EC production of these products is marginally affected

Figure 4. Changes in world price of selected products due to EC policies.

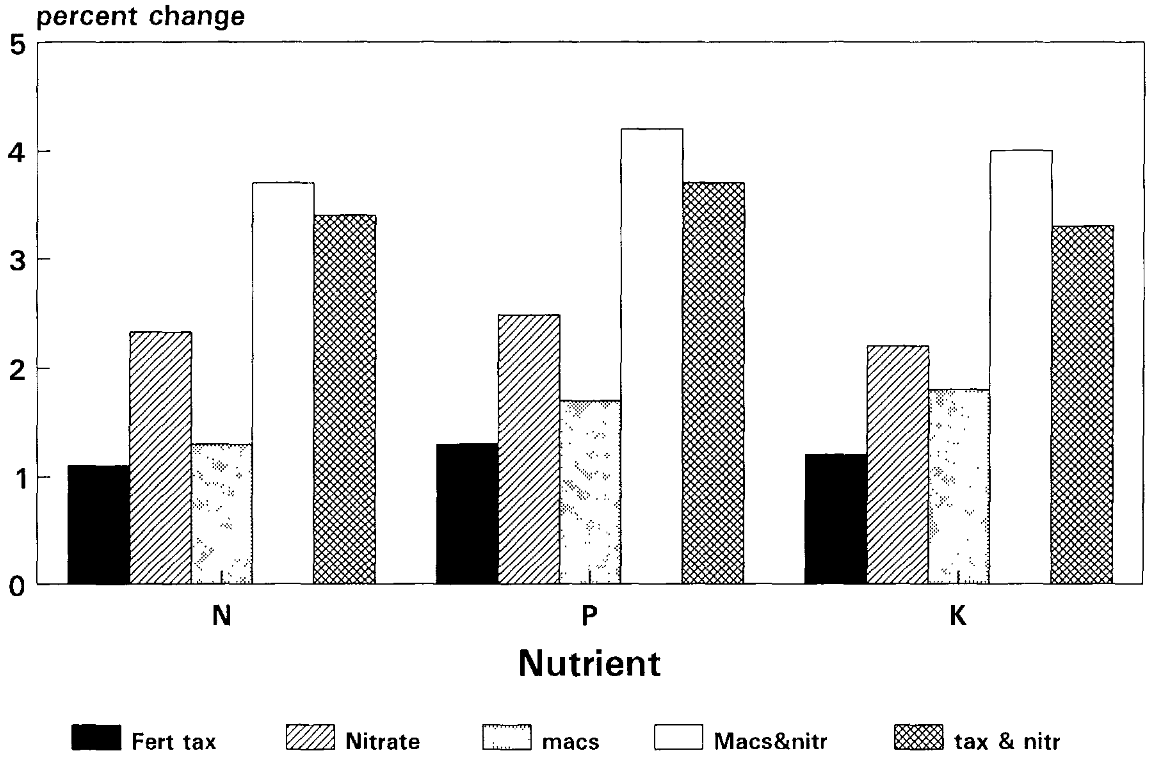


by the Directive, but because of declines in livestock production, feed demand for these products declines, resulting in increased exports and falling world prices.

Additionally, EC policies have spillover effects on the environment of other countries. As these countries respond to changing world prices and adjust output, their environmental quality is affected. Figure 5 illustrates this for the U.S. In response to increasing world prices, U.S. agricultural production expands. Demand for chemical fertilizers increases and increased livestock production leads to additional animal effluent. The net effect is an increase in the nutrient delivery to the soil, implying increased potential for environmental degradation. EC policies, intended as a means to improving environmental quality in the EC, may result in environmental degradation in third countries. Interestingly, the EC policy with the smallest potential for environmental damage to the U.S. is the fertilizer tax. Net nutrient deliveries in the U.S. increases the least with this scenario. From a global perspective, this result further justifies the polluter pays principle--efficient policies are those that internalize the externality. The fertilizer tax scenario not only leads to the greatest reduction in nutrient deliveries in the EC with the least damage to EC farm income, but it also leads to smallest increase in nutrient deliveries in the U.S.

How do our results compare to results from other studies? There are very few studies that analyze the policy scenarios examined in this paper and fewer still that include an agronomic component to measure environmental load. Furthermore, of the relevant studies there are differences in commodity coverage or modelling approach. Hence, direct comparisons are not possible. In cases where comparisons are possible, indications are that our results are reasonable. For example, Abler and Shortle(b) analyzed CAP reform and although their commodity coverage and model design is different from ours, their interpretation of CAP reform is similar to ours. They report that CAP reform leads to a 96 percent reduction in wheat supply and a 28

Figure 5. Effects of various EC policies on U.S. nutrient balance.



percent drop in land rent whereas we obtain an 8 percent reduction in the supply of wheat and an 8 percent reduction in land rent. The differences in results between the two studies are similar for the other commodities. The direction of the change due to CAP reform is the same for both models, however, the magnitude of the change is substantially different. Our results suggest much smaller (and more politically acceptable ?) output affects compared to those reported in Abler and Shortle.

As mentioned previously, GRA examined the effects of a 50 percent fertilizer tax. Since GRA model does not include inputs, they impose the tax through adjustments in the producer price of crop commodities. They found that a 50 percent fertilizer tax has a marginal effect on crop production. Production of each modeled crop declined one percent or less. Since changes in EC production were minimal, changes in world prices were also minimal. The world price of each modeled crop increased less than one percent. Our modeling framework suggests that the 50 percent fertilizer tax has a larger impact (in absolute value) on EC production. Furthermore, the production of all commodities, not just crops, is affected because of jointness. Furthermore, given the small output effects generated by GRA, one would be tempted to conclude that the environmental impact of the fertilizer tax will be minimal. Our results illustrate this is not the case. Our results also demonstrate the need to include inputs in policy-oriented trade models. Such models are more useful than conventional policy-oriented models that have been used to date, especially for exploring environmental consequences of various policies. As demonstrated, policies that affect output prices have different implications on resource use and potential environmental degradation from policies that affect input prices directly.

Concluding Remarks

We presented a net-trade model and incorporated agronomic parameters to examine the economic and environmental implications of various EC policies. Our results suggest that there are environmental benefits associated with CAP reform. However, if the EC policy objective is to reduce delivery of nitrogen and phosphorus to the soil, a more efficient policy is to tax fertilizer consumption. The results suggest that for the EC, this policy, which adheres to the polluter pays principle, leads to greater social benefits and smaller private costs. EC farm income declines proportionately less and nitrate and phosphate abatement is greater when fertilizer consumption is taxed in contrast to CAP reform or the Nitrate Directive.

The results further demonstrate that when products are traded, there are spillover effects even to strictly domestic policies. Finally, the results demonstrate that trade models need to include inputs and environmental variables in order to provide accurate assessments of policy changes on the environment. Policies that reduce output the most do not necessarily lead to a greater improvement in environmental quality. Hanley stated that most environmental research does not predict significant abatement in nitrate from policies oriented toward outputs. Our results support this conclusion within the context of a trade model.

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