Leakage and Comparative Advantage Implications of Agricultural Participation in Greenhouse Gas Emission Mitigation

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Abstract

The world is moving toward efforts to reduce greenhouse gas emissions. Net emission reduction efforts may involve the agricultural sector through options such as planting of trees, crop and livestock management changes, and production of biofuels. However, such options can be competitive with domestic food production. In a free trade arena, reduced domestic food production could stimulate increased production and exports in other countries, which are not pursuing similar mitigative courses of action. As a consequence, net emission reductions in implementing countries may be offset by activities stimulated in other countries. In addition producers in countries where agriculture is subject to greenhouse gas mitigation have expressed concern about their competitive position to countries which are not trying to reduce net emissions.

In this study, we examine the competitive effects of differential mitigation efforts on agricultural food production and on international trade. We assume that the average U.S. production cost increase of mitigation compliance would also occur in other complying countries. Three alternative implementation are considered: 1) unilaterally by the U.S., 2) by all

Kyoto Protocol Annex I countries and 3) globally. The results, which are only suggestive of the types of effects that would be observed due to the simplifying cost assumptions, indicate compliance causes supply cutbacks in regulated countries and increases in non-regulated countries. In addition, the study results show that U.S. agricultural producers are more likely to benefit from a Kyoto Protocol like environment but that consumers are likely to be hurt in terms of their agricultural welfare.

Keywords

Emission Leakage, Agricultural Sector Model, Greenhouse Gas Policy, Mitigation, Carbon Sequestration

Introduction

Society has increasingly become concerned with the potential climate implications of greenhouse gas (GHG) emissions, and GHG atmospheric concentration. The Intergovernmental Panel on Climate Change, projects that GHG concentrations will cause global average temperature to increase by 1.4 to 5.8°C between 1990 and 2100 (IPCC, 2001). In turn such warming is predicted to alter agricultural production, raise sea level, change habitat boundaries for many plants and animals, and induce a number of other changes (Cole et al., 1996, USGCRP, National Assessment Team, 2000). Numerous strategies have been proposed to mitigate GHG emissions, a number of which involve agriculture and forestry (McCarl and Schneider, 2000 and 2001). In particular, agriculture and forestry may be important players due to their emissions levels. According to the IPCC summary report by Houghton et al., agriculture is one of the primary emitters of GHG with over 50 percent of nitrous oxide and about 40 percent of methane emissions worldwide. While carbon emissions from farming activities are relatively small, the combined agricultural and forest sectors cause large emissions due to land use changes. The two sectors contain substantial potential to sequester carbon via sinks or offset carbon emissions via biofuels.

GHG concentrations and their climate effects are global, thus all countries will share the benefits from GHG emission (GHGE) mitigation, but in the absence of widespread trading and emission caps only countries adopting mitigation measures will directly bear the costs. This implies two things.

- ❖ Producers in emitting industries and users of emission intensive products within countries mitigating GHG emissions are likely to experience increased production costs. Mitigation actions are likely to make fuel, fertilizer and other petrochemicals prices rise along with raising the possibility of emissions related payments for land use change, fertilizer related nitrous oxide emissions, livestock related methane/nitrous oxide emissions and rice related methane emissions.
- ❖ Competing producers in non-adopting countries may gain a comparative advantage leading to

- o increased trade market share and
- o expanded GHG emissions reflecting more intensive production in these countries.

This paper reports on a first order examination of the producer welfare, comparative advantage, and emission leakage impacts of differential GHG emission (GHGE) mitigation efforts. Specifically, we examine international production and U.S. agricultural sector implications under: 1) unilateral U.S. GHGE mitigation implementation, 2) developed country implementation (in those countries falling within the Annex I[a] list under the Kyoto Protocol and 3) global implementation.

Background

The welfare and leakage effects of agricultural GHG mitigation have been the subject of several studies. Let us review these categorized by the major issues in the bullets above.

Production cost and producer welfare

The implications of pursuing agriculturally based GHG mitigation for domestic production cost and farm income has been a concern of producer groups. For example, in 1998 the U.S. Farm Bureau advanced a position that it will not support ratification of the Kyoto Protocol (KP) unless principal international market competitor countries were also covered by the KP terms (Francl, 1997, Francl, Nadler and Bast, 1998). Francl and associates asserted that substantial farm income (up to 84%) would be lost due to increases in fuel prices. However, later analyses that considered factor substitution, product price adjustments and consumer demand reactions (McCarl et al. 1997; USDA, 1999, Antle at al. ,1999; Konyar and Howitt, 2000; and Peters et al., 2001) found producer welfare reductions of much smaller magnitudes (generally below 10%). Furthermore, none of these studies considered the effects of possible payments to farmers for carbon sequestration or taxes for methane and nitrous oxide emissions from livestock, fertilization, and other sources.

More recent work by McCarl and Schneider, 1999, 2001 examined the combined effects of higher input prices and possible payments for agricultural GHG offsets. They find the aggregated net impacts on U.S. agricultural producers to be positive after markets have adjusted. Similarly, Antle et al. 2002 argue that producer incomes will be enhanced by carbon payments but did not consider possible market price changes.

Across all of the U.S. studies mentioned above economic conditions were assumed to remain constant for agricultural producers of international trading partners of the U.S.[b] However, GHGE mitigation efforts are likely to be enforced or encouraged in the agricultural sectors of

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[a] The Annex I countries are those listed in Annex I of the United Nations Framework Convention on Climate Change.

[b] This is mentioned on page 41-42 of the USDA (1999) report has not been explored quantitatively.

some of these countries as well. The extent to which mitigation actions are implemented on a global scale may have important economic consequences for the agricultural sectors in both implementing and non-implementing countries, and for net GHGE reductions after leakage. These consequences will be investigated in this paper.

Shifts in Comparative Advantage

A rich literature has emerged on shifts in comparative advantage as caused by environmental regulation. The fundamental argument is that regulations in one country may shift production to other countries (Pethig, 1976). The overall literature on this topic was reviewed by Jaffe et al. who concluded that "…regulation clearly imposes large direct and indirect costs on society …"(p. 159) but that "there is relatively little evidence … that environmental regulations have had a large adverse effect on competitiveness" (page 157). This suggests that adjustments in production technologies may help mitigate the effects of regulations as found in the carbon tax related studies reviewed just above.

Leakage

Leakage occurs in a GHGE context when actions to offset emissions in one country stimulate additional production and consequent emissions in other countries. Several papers have examined the potential empirical magnitude of leakage when GHG abatement actions (e.g., emissions limits, carbon taxes, or tradable permits) are applicable to only a subset of the world's countries mainly in an energy context (e.g., Oliveira-Martins et al., 1992; Smith, 1998; Bernstein et al., 1999; Barker, 1999; Babiker, 2001). These leakage estimates range from negligible (Barker, 1999) to substantial (Felder and Rutherford, 1993), but typically range between 10 and 20 percent of targeted country emission reductions.

Agricultural and forestry related leakage studies have also been done. Wu (2000) examined leakage relative to the U.S. Conservation Reserve Program (CRP), which pays farmers to retire land from crop production. Using data from the Natural Resources Inventory, Wu estimated leakage to average about 20 percent within the U.S. through farmers adding additional lands. Leakage was also discovered in U.S. crop commodity programs (Brooks et al., 1992; Hoag et al., 1993). Alig et al. (1997) examined leakage in the forest sector and finding leakage rates for certain carbon sequestration projects above 100 percent. Sedjo and Sohngen (2000) examine international leakage resulting from the establishment of large-scale forest carbon plantations using a model of the global timber market and find leakage rates up to 40 percent.

None of these investigations, however, analyzed the international agricultural effects which we will attempt herein.

Scope of GHGE Reduction Implementation

In this paper we will examine the leakage and comparative advantage implications of three different international implementation and trading cases.

1. Unilateral implementation where a country or a group of countries decide to unilaterally implement GHG mitigation. This might happen today if a few developed

countries implement the KP but the U.S. does not or if the U.S. implements the President's Clean Air Initiative and the rest of the world fails to implement the KP. In these cases, the implementing countries would be expected to experience higher costs of domestic production yielding lower levels of their domestic production and exports, and higher prices. Simultaneously, non-implementing countries would be expected to increase domestic production and world market share thereby offsetting some of the GHG emission gains in implementing countries.

2. Partial global implementation where a relatively large group of countries implement GHG mitigation policies. This might have happened if the KP would be implemented by all Annex I countries but the Clean Development Mechanism (CDM) turned out to be an ineffective way of drawing other countries into GHG emission mitigating activities. In such a case, the Annex I countries would be expected to have a comparative disadvantage on average relative to Non-Annex I countries. The net impacts on individual Annex I countries and magnitude of emission leakage, however, might be different from Case I.
3. Global implementation where all countries implement a mitigation policy. This might have happened if the world would implemented the KP and involve also all Non-Annex I countries through mechanisms such as the CDM. In this setting, all countries would experience higher costs of production.

Modeling

To evaluate the three cases from above, we need a model that portrays global agricultural trade and simultaneously allows examination of detailed GHGE mitigation possibilities within implementing countries. A model with such global scope and regional detail was not available or practical to construct for this investigation. Thus, we used a model that satisfies some of the needed characteristics and combined it with an assumption laden analytical approach.

Specifically we used the U.S. Agricultural Sector and Mitigation of Greenhouse Gas (ASMGHG) model as documented by Schneider (2000) and McCarl and Schneider (2001). This model is based on the Agricultural Sector Model (ASM) as described in McCarl et al. (2001) and Chang et al. (1992) with the addition of soil type differentials (developed in conjunction with USDA NRCS) and a global trade representation via spatial equilibrium models for eight commodities as developed by Chen and McCarl (2000) and Chen (1999). The combined ASMGHG model considers agricultural production, consumption, and trade in developed and developing countries simultaneously. Overall characteristics of the model are discussed below.

General Structure of the U.S. Agricultural Sector Model

Like many agricultural sector models, ASMGHG is a price-endogenous mathematical program following the market equilibrium and welfare optimization concept developed in Samuelson (1952), and Takayama and Judge (1971). ASMGHG assumes individual producers and consumers cannot influence commodity or input market prices. Production and use of farming inputs are portrayed in 63 regions in the U.S. and for 28 foreign regions. Data on currently observed trade quantities, prices, transportation costs, and supply and demand elasticities were obtained from Fellin and Fuller (1997, 1998), USDA statistical sources (1994a, b, c; annual), and the USDA, SWOPSIM model (Roningen, 1991).

Modeling Greenhouse Gas Emissions and Mitigation Strategies

Schneider (2000) added a GHGE mitigation component to the United States part of ASM. This component introduces production alternatives and GHG net emission accounting to reflect the GHG consequences of changes in crop mix, tillage, irrigation, fertilization, afforestation, biofuel production and livestock management. Livestock management options involve: 1) herd size, 2) liquid manure system alterations on dairy and hog farms, 3) enteric fermentation management involving use of growth hormones for dairy cows and 4) stocker/feedlot production system adoption. A detailed technical description of all considered mitigation strategies is contained in Schneider (2000). In ASMGHG, the following GHG categories are accounted for:

- Direct carbon emissions from fossil fuels (diesel, gasoline, natural gas, heating oil, and LP gas) used in tillage, harvesting, or irrigation water pumping.
- Carbon emissions or sequestration arising from altered soil organic matter stimulated by adopted tillage system or land use change to and from croplands, forestlands and grasslands.
- Indirect carbon emissions from manufacture of fossil fuel intensive inputs (fertilizers, pesticides).
- Carbon offsets from biofuel production (ethanol, power plant feedstock via production of switchgrass, poplar, and willow) as well as associated and methane and nitrous oxide emission changes from biomass combustion.
- Nitrous oxide emissions from fertilizer usage.
- Methane emissions from enteric fermentation, and rice cultivation.
- Methane savings from manure management changes as well as both methane and nitrous oxide emission alterations from herd size alterations.

Individual emissions were converted to carbon equivalent measures using global warming potential from the 2001 IPCC report (23 for methane and 296 for nitrous oxide).

Obviously this GHG component only examines detailed emission management possibilities in the U.S. but not in the rest of the world. This limitation implies that global adjustment to GHGE mitigation incentives cannot simulated accurately outside the U.S. but instead is approximated using simplifying assumptions in the remainder of the analysis.

Experimental Results and Implications

Three alternative mitigation implementation scenarios are simulated. The first scenario assumes unilateral mitigation efforts in U.S. agriculture only. The second corresponds to a KP like situation with simultaneous implementation in all Annex I countries. The third involves worldwide implementation. Since we do not model the whole economy we simulate agricultural actions with an exogenously set carbon equivalent (CE) prices. All scenarios are analyzed for alternative prices ranging from 0 to 500 dollars per ton of CE.

Unilateral Implementation in Just the United States

The U.S. agricultural sector effects of a unilateral U.S. emission policy implementation over a range of CE prices are listed in Table 1 and 2, which show percentage changes from a zero CE price. Total CE emissions decline steadily as the price rises. At $100 per ton, net emissions of CE from U.S. agriculture are about zero with the realized levels of carbon sequestration from carbon sinks offsetting all agricultural emissions.

The results in Tables 1 and 2 confirm that emission reductions are obtained at the expense of conventional crop production. Increasing CE prices cause decreases in U.S. production and exports along with increases in prices for conventional agricultural commodities. In addition, since the U.S. is a major trading country, production in other countries is influenced and comparative advantage shifts partially to those countries. Across the range of prices substantial leakage can be observed. For example, at a $100 price U.S. production falls by 6.5 percent while global production only falls by 0.4 percent and production in non U.S. Annex I and non Annex I countries expands by 2.7 percent and 12.2 percent, respectively.

Welfare impacts for unilateral implementation of GHGE mitigation efforts in the U.S. are listed in Table 2. U.S. consumers' surplus decreases monotonically with CE-price increases. Producers' surplus on the other hand is only reduced for CE-prices below $55 per ton but increases above that level. The change in producers' surplus arises from both the traditional commodities markets and the CE-price induced GHG payments/charges. These payments/charges include: 1) charges at the CE-price for emissions from land use change, fuel use, livestock, rice, fertilization and other emissions; 2) higher costs for fertilizer and other inputs due to the embodied emissions in their manufacture; 3) sequestration payments for increased soil, grassland and forest carbon storage; and 4) payments for the production of biofuels. In the U.S. only implementation case, producer gains from higher commodity prices more than offset losses from lower levels of domestic production. GHG accounting results in a net cost if emissions charges outweigh sequestration and biofuel payments. For prices below $100 per ton, net emissions are positive resulting in additional sectoral cost. Above this price, the amount of carbon sequestration and biofuel related carbon offsets exceed emissions and thus provide additional sectoral revenue. The differences between scenarios results indicate the relevance of international adjustment.

Trade surplus measures the welfare of consumers and producers in non-U.S. countries attributable to trade of agricultural commodities. If the U.S. alone implements agricultural provisions for mitigation, the impact on welfare in other countries is negative with the magnitude getting bigger as the CE-price increases. Consumer losses in non-U.S. countries exceed producer gains. The results also indicate what could happen under a rest of the world implementation of Kyoto without U.S. participation. Namely, one would expect the mirror image of the findings here with market share flowing to the U.S. and a reversed leakage effect. However, such a KP realization perhaps combined with the U.S. 18 percent greenhouse gas intensity reduction climate change strategy may lead to very low carbon prices in the $3 to $10 range as suggested by recent analyses by integrated assessment groups (i.e. Babicker et al., 2002).

Representing Mitigation Induced Shifts in ROW Countries

Mitigation efforts in regions outside of the U.S. could not be modeled explicitly because we did not have detailed data of production technologies in foreign regions, rather having excess supply curves. Thus, a simplifying assumption was made to depict the supply shifts in foreign countries. Namely, the average price increase and production decrease observed for each traded commodity in U.S. agriculture was assumed to proportionally apply to agricultural production in other countries. Thus, if for a given CE price average U.S. prices for rice went up by x percent and production down by y percent, the same shift was applied to rice supply in foreign regions in all implementing countries. We used this crude approximation because alternative reasonable assumptions were not available[c]. Empirical results derived from supply shifts in non-U.S. countries should therefore be considered illustrative but not definitive. In presenting our empirical results we will focus on a comparison between the various implementation scenarios examined.

Full Annex I Implementation

The results for full Annex I country implementation are shown in Table 1. U.S. agricultural production and exports decline but not as much as in the unilateral case. This diminished response reflects the fact that only the non-Annex I countries now have comparative advantage over U.S. agriculture. Leakage occurs in non-Annex I countries whose production expands by 20 percent at a $100 CE price. Prices of traded agricultural commodities increase slightly more under full Annex I implementation. The welfare results show overall U.S. welfare is reduced less but consumers loose even more than under unilateral implementation. On the other hand, U.S. producers always gain.

Annex I countries' net exports are highest under U.S. unilateral implementation but lowest if all Annex I countries are subjected to agricultural mitigation policies. Equivalently, non-Annex I countries' net exports are highest under full Annex I country implementation. All of these observed changes become more substantial the more the CE-price increases. Note that the Annex I accounts do not involve the U.S. to avoid double counting.

Total emission reductions from U.S. agriculture are almost identical for all scenarios up to CE-prices of $55 per ton (Figure 1). Above $85 per ton of CE, additional emission reductions become smaller under full Annex I country implementation. For example, at a CE-price of $100 per ton, emissions reductions are about 11 percent lower than for U.S. alone implementation. U.S. emissions rise because higher commodity prices lead to more intensive production and less adoption of sequestration and emission control activities. This would be offset by emission reductions in the Annex I agriculture but we cannot quantitatively represent that in our model. If

[c] It is also not clear if the cost increases elsewhere would be bigger or smaller as expansions elsewhere may involve new land development which could be subject to substantial carbon taxes.

emissions per unit of output were relatively constant, changes in production would provide an approximation of changes in emissions.

Global GHGE Mitigation Implementation

Provisions in the KP permit emission credits to Annex I countries for GHGE reduction projects in non-Annex I countries, which are sponsored by Annex I countries. If such provisions were implemented, low cost activities in agriculture could be exploited globally. This situation is represented by the last scenario, where production globally is shifted using the U.S. average price and cost shift assumptions as explained above. Tables 1 and 2 list the main impacts. We find increased U.S. market shares at the expense of foreign countries, particularly the non-Annex I ones. Leakage is contained with all regions decreasing aggregate production. Prices rise more than in the U.S. unilateral or KP cases. Note this is a property of the assumptions as we have successively shifted more and more of the total model supply curve.

U.S. producers welfare gains are highest in such a situation and consumers losses. Global mitigation efforts affect the level of emissions. The more countries implement GHGE mitigation policies, the smaller are net emission reductions from U.S. agriculture. For example, at a CE-price of $100 per ton, emissions offsets are about 21 percent lower than for U.S. unilateral implementation.

Conclusions

The prospect of greenhouse gas emission mitigation policies has stimulated a wide search for cost-efficient emission reduction methods. Agriculture including forestry has been proposed as a relatively cheap source of net emission reductions. However, concerns have been expressed about agricultural abatement policies being hosted in only a subset of all countries. The comparative advantage gained in the agricultural sectors of non-host countries could distort trade patterns, harm domestic agricultural producers in host countries, and lead to increased emissions in non-host countries. Our investigation in the context of the U.S. agricultural sector, confirm tradeoffs between agricultural emission reductions and traditional food and fiber production. In particular, the two most carbon abating strategies, afforestation and production of biofuels, cause the greatest decline in traditional agricultural production. If the positive relationship between agricultural production and agricultural emissions also holds in foreign countries, then our results imply increased greenhouse gas emissions in non-host countries. However, the consequences of such emission leakage would not necessarily be incurred by non-host countries but by those countries, which are most vulnerable to climate change.

The findings of this paper have several implications for policy makers. First, if national agricultural greenhouse gas mitigation policies are not synchronized with foreign greenhouse gas emission policies, substantial leakage may occur. For example, if an international treaty like the Kyoto Protocol were implemented, emission reductions in Annex I countries would most likely be accompanied by emission increases in Non-Annex I (developing) countries. Several alternatives exist to prevent emission increases through agriculture in non-host countries. For example, the Kyoto Protocol proposes Joint Implementation (JI) and CDM, through which host countries could establish incentives for agricultural producers in non-host countries to avoid emission intensive technologies.

Second, U.S. farmers' would benefit from a larger number of countries hosting greenhouse gas emission mitigation policies. The more countries abate greenhouse gases through the agricultural sector, the higher agricultural commodity prices would be. Income support has been a longtime objective of American farm bills and carbon payments/taxes contribute to farm income support but at the expense of consumers. The unanswered general equilibrium question is whether the consumer is better off if GHGE mitigation is carried out in agriculture as opposed to elsewhere in the economy but this is beyond the scope of this study. If the U.S. and other potential host countries would financially support CDM incentives in non-host countries, i.e. Non-Annex I countries, a portion of that expenditure could pay back because higher agricultural prices eliminate the need for expensive farm bills.

Third, if implementation of an equivalent mitigation policy or CDM in all countries is politically infeasible, trade policies might need to be negotiated to discourage increases in non-participating countries and to discourage leakages.

Fourth, credits for agricultural emission abatement could be discounted to reflect likely emission leakage through agricultural sectors in non-host countries. This adjustment would imply higher discount factors for agricultural mitigation strategies, which divert farmland. Such strategies are afforestation and biofuel production. However, strategies, which are complementary to traditional food and fiber production, such as reduced tillage, would remain eligible for full credit. A differential treatment of agricultural mitigation strategies would then increase the relative adoption of complementary strategies and thus reduce leakage.

Fifth, consumers of agricultural products incur higher expenses due to price increases. The more countries participate in mitigation efforts, the higher are losses to both domestic and foreign consumers. Consequently, more people may become dependant on governmental aid to ensure sufficient food consumption.

There are also implications for modelers. Our results show deviation from the results of previous studies, which only looked at fossil fuel based carbon emission taxes. Consideration of emissions from other sources such as methane, nitrous oxide and land related carbon releases are also important and should be considered in future studies. The results also show international adjustments and potential leakage are important modeling concerns.

The quantitative effects presented in this study reflect several simplifying assumptions and uncertain data, and should therefore be considered preliminary. While efforts will continue to improve the underlying data, the basic nature of our findings is unlikely to change. Possible extensions to our work could also involve a general equilibrium analysis.

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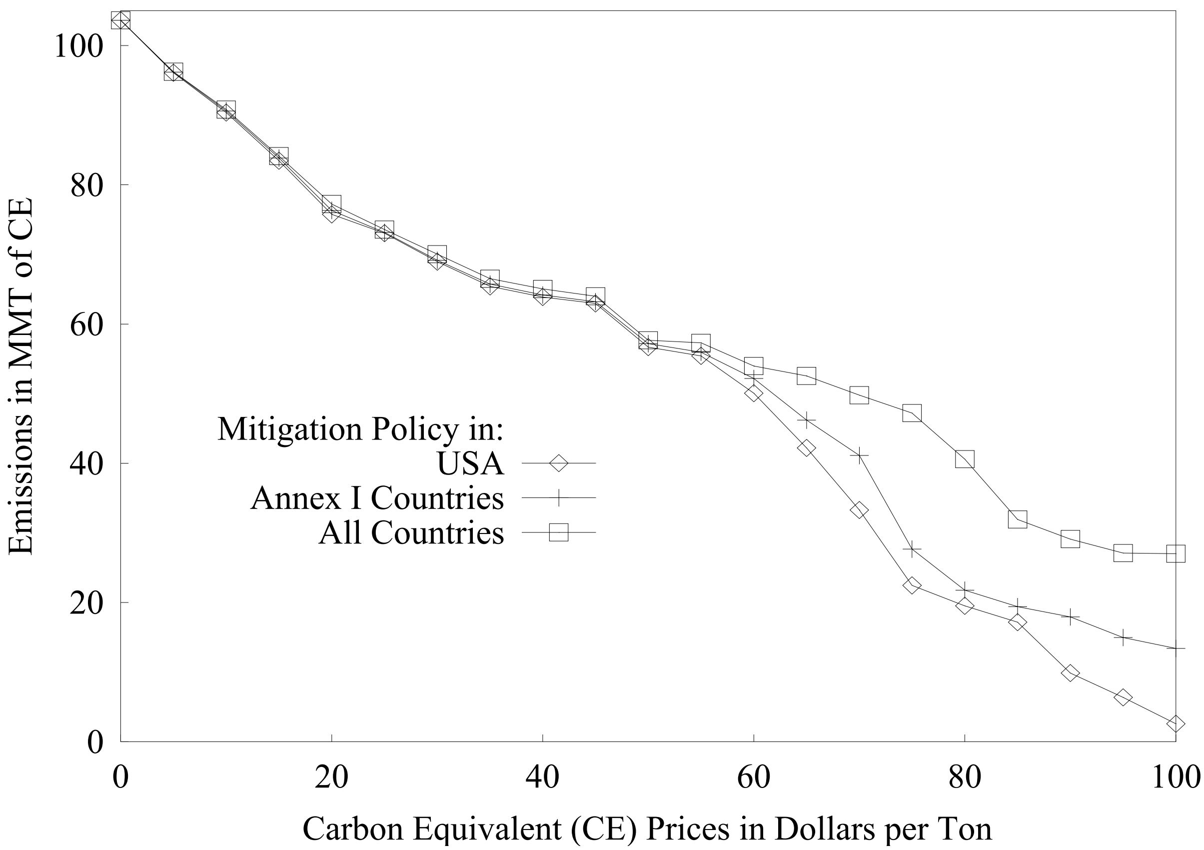

Figure 1 Carbon Equivalent Prices and Net Carbon Emissions from U.S. Agriculture

Table 1 Impacts of Carbon Equivalent Prices on Fisher Ideal Price and Quantity Indices of Production, and Trade[d]

	Mitigation Policy in								
	US Only			US and Annex I Countries			All Countries		
	$10	$20	$100	$10	$20	$100	$10	$20	$100
U.S.									
Production of Traded Crops	99.60	99.09	93.47	99.87	99.64	97.09	100.52	100.59	105.11
All Production	99.33	99.04	97.53	99.93	99.16	97.43	99.47	99.32	98.59
Overall Agricultural Product Prices	100.57	101.42	110.60	100.76	101.82	113.44	101.22	102.28	121.68
Exports	98.84	97.44	81.77	99.93	99.50	97.65	102.19	103.28	126.92
Production of traded commodities in rest of world									
Global production	99.96	99.93	99.60	99.95	99.91	99.44	99.98	99.94	99.71
Annex I Countries (excluding U.S.)	100.36	100.69	102.66	99.51	98.81	92.31	99.61	99.94	99.25
Non-Annex I Countries	100.32	100.93	112.22	100.49	102.15	120.13	96.89	93.85	57.60

[d] Note: Trading crops production includes the production for corn, soybeans, sorghum, rice, and four kind of wheat defined previous; all production includes production for all primary products (crops and livestock) defined in the model.

Table 2 Impacts of Carbon Equivalent Prices on Agricultural Sector Welfare (Million Dollars) and U.S. Emissions (MMT)[e]

	Mitigation Policy in								
	USA Only			Annex I Countries			All Countries		
	$10	$20	$100	$10	$20	$100	$10	$20	$100
U.S. Consumers' Surplus	-540 (-0.05)	-1,240 (-0.10)	-9,159 (-0.77)	-607 (-0.05)	-1,536 (-0.13)	-11,355 (-0.96)	-749 (-0.06)	-1,976 (-0.17)	-17,607 (-1.49)
Net U.S. Producers' Surplus with GHG tax/pay	-207.32 (-0.46)	-161.70 (-0.36)	7,430 (16.35)	-71.61 (-0.16)	449 (0.99)	13,037 (28.69)	264.39 (0.58)	1,479 (3.26)	27,336 (60.15)
Ag Producers' Surplus without GHG Pay	696 (1.53)	1,353 (2.98)	7,689 (16.92)	835 (1.84)	1,976 (4.35)	14,380 (31.64)	1172 (2.58)	3,024 (6.65)	30,037 (66.10)
Total Welfare without GHG Pay	156 (0.01)	113 (0.01)	-1,471 (-0.12)	228 (0.02)	440 (0.04)	3,025 (0.25)	424 (0.03)	1,048 (0.09)	12,430 (1.01)
Total GHG Payments to Agriculture	-903	-1,514	-259	-907	-1,526	-1,342	-908	-1,545	-2,701
Net Welfare	-748 (-0.06)	-1,402 (-0.11)	-1,730 (-0.14)	-678 (-0.06)	-1,087 (-0.09)	1,683 (0.14)	-484 (-0.04)	-497 (-0.04)	9,728 (0.79)
Foreign Country Surplus	-210 (-0.09)	-395 (-0.16)	-3,516 (-1.45)	1012 (0.42)	2,140 (0.89)	17,902 (7.40)	2557 (1.06)	5,360 (2.22)	42,156 (17.44)
Global Agric. Welfare	-54 (-0.003)	-282 (-0.02)	-4,986 (-0.34)	1240 (0.08)	2,579 (0.18)	20,928 (1.42)	2981 (0.2)	6,408 (0.44)	54,586 (3.71)
U.S. Agricultural GHG Emissions	90.37	76.74	2.58	90.61	76.32	13.40	90.81	77.23	27.01

[e] The numbers in parentheses give the percentage change with respect to the zero CE-price scenarios. Gross welfare items exclude GHGE charges/payments.

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