Trade, the Environment, and Impacts on State Agricultural Exports

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International trade theory predicts that the relative level of a country's resource endowments, trade policy, environmental regulations, and level of technology would jointly determine production specialization and trade pattern of the country. This study develops state export share and alternative environmental risk models to evaluate the effects of resource endowments, prices, and environmental risk factors on agricultural exports and environment. A simultaneous system of the environmental risk and export share models was estimated by using the nonlinear estimation method outlined in RATS (2009). The results reveal that crop prices, state GDP, state farm GDP and technological changes were found to be major determinants of the state export shares. The results also suggest that NAFTA had no negative effect on the environment. The study found that the European Union (EU) and expansion of its membership led to significant reduction in state agricultural exports due mainly to the effect of trade diversion in the EU expansion.

INTRODUCTION

The impact of environmental policy on international trade continues to generate a great deal of attention among both academicians and policy makers. The relationship between trade and environmental standards is increasingly a hotly debated issue. Environmental concerns are routinely brought to the negotiation table during free trade negotiations.

The main concern of the environmental group is that any free trade agreement reduces tariff and/or non-tariff trade barriers among member countries and increases environmental risk through overuse off fertilizers and chemicals to maximize productivity.

For example, under the North American Free Trade Agreement (NAFTA), tariffs and non-tariff barriers were gradually eliminated on goods traded among the United States, Canada and Mexico which resulted in increases in trade volume among these countries through trade creation and diversion effects. The increases in tradeflows are due to increased productivity through production specialization and the substantial use of production resources. Natural resources could be overused and/or depleted, leading to environmental quality degradation. On the other hand, the trade advocacy group supporting free trade claims that open trade would lead to innovation in technology that is environmentally friendly and could increase productivity. However, enforcing abatement technology to meet environmental standards may impute costs to producers and result in comparative disadvantage to the producers and exporters. This study examined the relationship between trade and environmental factors and analyzed the environmental consequences of free trade. The study used selected environmental factors and analyzed the impact of free trade agreements, such as NAFTA, on the environment and identified the effects of the environmental factors on state agricultural production and exports.

Previous studies on the subject have addressed trade and environmental issues through use of aggregate data in general good trade (Harrigan, 1997; Baek & Koo, 2009) or semi aggregate data in agricultural trade (Managi & Karemera, 2005). The impact of state productivity was discussed in previous studies by Ball, Gollup, Kelly-Hawke, and Swinland (1999), Ball, Butault and Nehring, (2001), and Caves, Christensen and Diewert (1982a, 1982b). The current study expanded previous literature by increasing the period of study and introducing specific environmental factors. A system of structural equations was specified and estimated for this study. Furthermore, technical advances in agricultural as well as efficiency changes arising from agricultural production and trade activities were derived and incorporated into the model. Thus, it was hypothesized that technologies, prices, and factor endowments, including environmental factors, are significant determinants of agricultural exports.

Environmental factors considered in this study represented the level of pollution and degradation from pesticides and chemicals used to increase agricultural productivity. Published indexes of ground water pollution in agricultural farm land and levels of CO_2 were used to estimate the environmental damage model. This study addressed the risk to human health and fish life from chemical and pesticide runoffs and leaching. The study examined whether NAFTA is good or bad for state agricultural trade and environment. The impact of another major free trade agreement such as the European Union (EU) on state agricultural trade was also evaluated within the framework of international trade (Leamer & Levinsohn, 1995). The findings will contribute to the wealth of literature on environmental and trade policy study and could be an instrument of trade negotiators and policy makers in trading countries.

A system of structural and reduced form equations of agricultural export shares and environmental risk models were specified following Harrigan (1997) and Antweiler and Trefler (2001). The system was estimated by a nonlinear system estimation method outlined in Regression Analysis of Time Series, commonly known as RATS (2009).

METHODOLOGY

This study used state-level data to examine the relationship between trade and environment, mainly the impact of trade openness on state environmental quality. The model developed for this study was based on the framework developed by Antweiler and Trefler (2001) to account for environmental performance under NAFTA and EU (Grossman & Krueger, 1993) and applied the methodology of Harrigan (1997) to examine the relationships between trade and environmental standards. Harrigan specified the export shares as a function of factor endowments including environmental stringency and technology. Van Beers and Van den Bergh (1997) suggested that environmental regulations influence trade patterns. This study estimated the impact of endowment and factor supplies, prices, and environmental risk factors on exports and the impact of free trade on environmental risk factors in Harrigan's (1997) framework. Based on the previous studies, we specified two models: export share model and environmental model based on environmental risk factors.

Development of the Export Share Models

The export share model was specified on the basis of the modified Heckscher-Ohlin and Ricardian model (Harrigan, 1997). Consider the small open economy model characterized by fixed factor supplies, constant returns to scale (CRS), and perfect competition. The general equilibrium of this economy is to maximize the value of final output. A common formulation of this maximization problem was given by

$$\begin{aligned}&\mathbf{r}(\mathbf{p},\mathbf{v},\theta)=Max\ \theta\,\mathbf{p}\,\mathbf{y}\\&subject\,to\,\mathbf{y}\in Y(\mathbf{v}),\ \mathbf{p},\mathbf{y}\in \mathrm{R}^n,\mathbf{v}\in \mathrm{R}^m\end{aligned} \tag{1}$$

where r (p, v, *and* θ) is the revenue function, y is the final good vector, p is the vector of final goods price, Y (v) is convex production set for endowments v, *and* θ is the level of productivity relative to some base periods. The gradient of r(p, v, θ) with respect to p yields the vector of net output supplies y(p, v, θ) as long as the revenue function r(p, v, θ) is twice continuously differentiable, which requires smooth substitutability among factors and at least as many factors as goods ($m \geq n$). Following Harrigan (1997) and Redding and Vera-Martin (2001), we specified the export share equation based on equation 1, as a function of output prices, variables representing natural resource endowments, technical progress (TC) and efficiency change (EC) as follows;

$$s_{jt} = f(p_{it}, v_{it}, tc_{it}, ec_{it}\ e_{it}) \tag{2}$$

where i is an index for individual state and t is an index for time, p and v represents vectors of output prices and resource endowments, respectively. TC and EC represent technical progress and efficiency changes, respectively. The term e is an independently and identically distributed error term.

An empirical export model for individual states should include additional economic variables affecting exports directly or indirectly. The variables are state per capita GDP (PGDP) to represent income level in the state, agricultural GDP to represent total agricultural production in the state, and regional free trade agreements such as NAFTA and EU. Thus, equation 2 in state i and time t is re-specified under a double-log functional form as;

$$\begin{aligned}InS_{it} = \beta_0 + \beta_1 lnP_{it} + \beta_2 lnFGDP_{it} + \beta_3 lnPGDP_{it} + \beta_4 NAFTA_t + \beta_5 EU_t\\ + \beta_6 PI_{it} + \beta_7 EC_{it} + \beta_8 TC_{it} + lne_{it},\end{aligned} \tag{3}$$

where S_{it} represents the share of state i's agricultural export to its GDP in time t, P_{it} represents average export price, FGDP represents state farm income representing production and export capacity of the state, PGDP is per capita GDP, representing personal income and living standard in state i, NAFTA and EU are dummy variables representing the North American Free Trade Agreement and European Union, respectively; PI represents pollution index in each state, EC represents changes in production efficiency and TC denotes technical progress in crop production.

It was hypothesized that increased farm exports come from increased domestic production and may possibly have affected environmental policy to control pollution intensity. Prices of agricultural commodities were expected to be positively related to export share since increases in commodity prices stimulate agricultural production. It was assumed that state PGDP is negatively related to export share mainly because an increase in personal income tends to increase domestic consumption and adversely affect export. Technical changes and efficiency changes were used to present the impact of productivity on trade and were expected to have positive impact on export share.

Environmental Damage Model

It is important to notice the relationship between export share and variables representing pollution. Regulations on pollution affect production and consequently export. On the other hand, export share also affects the level of pollution in a state. To investigate how does export promotion under globalization affect environmental degradation in each state, this study used state ground water pollution from chemical and pesticide contents and air pollution as measured by CO_2 and SO_2 levels. The impact on risk to human health and fish life of chemical and pesticide runoffs and leaching, as indicated by respective indexes, was assessed. Harris, Konya, and Matyas (2002) analyzed the environmental consequences of free trade. Antweiler et al., (2001) used a general equilibrium framework of world trade to determine how elimination of trade barriers affect pollution levels in trading countries. They assumed that pollution is proportional to output and derived a pollution emission model as follows:

$$\begin{aligned} \ln Z_{kt} &= \alpha_1 \ln S_{kt} + \alpha_2 \ln \kappa_{kt} + \alpha_3 \ln r_{kt} + \alpha_4 \ln m_{kt} + \alpha_5 \ln \theta_{ekt} \\ &\quad + \alpha_6 \ln w_{kt} + \alpha_7 \ln I_{kt} + \alpha_8 s_{kt} + \sum \alpha_{9z} D_k + \sum \alpha_{10t} \ln D_t + \varepsilon_{kt} \end{aligned} \tag{4}$$

where Z represents an index of pollution level, S is industry scale, k is capital/labor, *r* is land/labor, *m* is intermediate input/labor, *w* is water/pesticide pollution abatement expenditure as a proxy for pollution abatement effort, I represents income, s is trade intensity defined by (export + import)/GDP, D_k and D_t are dummy variables for state *k* and year *t*, respectively. This study used capital/labor, intermediate input/labor and land/labor as factor abundance[1]. All other variables have been previously defined. Formal mathematical derivations are explained by Antweiler et al., (2001), and Ball et al., (2001) with additional applications available in Managi and Karemera (2005).

It was assumed that the amount of pollution increased with expanded economic activity if the nature of the economic activity remained unchanged. Grossman and Krueger (1993), Copeland and Taylor (1994, 1995), and Antweiler et al., (2001) proposed the decomposition of trade's effect into scale, composition, and technique effects that have been useful for the study of trade and environment (Färe et al., 1994). The scale effect explained the negative environmental consequences of scalar in economic activity. The composition effect explained how trade-induced changes in the composition of output affect pollution concentrations. Trade liberalization will lead countries to shift resources into the sectors that make intensive use of its abundant factors. The technique effect explained the positive environmental consequences of increases in income that call for cleaner production methods.

Antweiler et al., (2001) employed GDP as a proxy for technique effect since rising incomes were associated with cleaner production methods and brought about positive environmental outputs. Thus, real income gain *indirectly* created the technique effect. Technical impact was composed of three effects: environmental effect, θ_e, pollution abatement effort, w, and income effects, *I*. Antweiler et al., (2001) used trade intensity to represent degree of globalization. However, this study used export share, *s*, as a proxy for trade openness[2] since import data was not available for each state. In addition, the trade intensity variable only captured the partial effects of trade liberalization or trade openness on environmental outputs. This was because decreases in trade restrictions alter the scale of output, composition, and income per capita.

Agricultural exports played an important role in U.S. trade, providing 18% of all 2006 total income from exports (USDA, 2008; Council of Economic Advisers, 2003). Pesticides and chemicals are widely used in the agricultural sector and contribute to agricultural production. Pesticides and chemicals, however, pose potential risk to human health and the environment. The risks include contaminated surface water and groundwater through pesticide runoff and leaching. Furthermore, pesticides affect the quality of water available for public use, consumption of drinking water, and water use for recreational purposes. In addition, chemical use affects the CO_2 and SO_2 concentration in the environment. Chemicals also affect human and fish life through chemical and pesticide runoffs and leaching in addition to abatement costs (Paul et al., 2002). Thus, this study assessed the impact of risk to human health and fish life as indicated by the respective indexes. If environmental regulations are effective, environmental damage or risks decrease consequently. Ground water pollution index (GWP), including the index of risk to human health from exposure to pesticide runoff (HFR) or the index of risk to human health from exposure to pesticide leaching (HFL), and indexes of threats to fish life from runoffs (FFR) and leaching (FFL)[3] were included in the impact analysis. In addition, the amount of ccarbon dioxide (CO_2) and sulfate dioxide (SO_2) were used as indications of air pollution and environmental damage. Consequently, the environmental pollution model was specified as:

$$\mathbf{PI}_{it} = \beta_0 + \beta_1 \ln S_{it} + \beta_2 \ln FGDP_{it} + \beta_3 \ln PGDP_{it} + \beta_4 OA_{it} + \beta_5 CA_{it} + \beta_6 NAFTA_t + \beta_7 EU_t + \beta_8 P_{it} + \ln U_{it}, \qquad (5)$$

where PI represents pollution level in each of the categories mentioned above, and OA and CA represent operational and capital abatement, respectively. Other variables were defined previously.

The system of equations (3) and (5) was estimated by using a nonlinear estimation method provided in RATS (2009). The system is a simultaneous system representing the export share model and pollution models with the implied assumption of cross correlations through error terms. Additionally, to further address the issues of endogeneity of pollution indicators we estimated two-equation systems of the export share model and each of the pollution models by using the same nonlinear estimation method.

EMPIRICAL RESULTS

Data on export share were collected from the Economic Research Service (ERS) of the United States and from the Department of Agriculture in various issues. Export values for each state by commodity were based primarily on a state's share of production of the exported commodities. Export share is a ratio of value of total state export to total state farm cash receipts. All environmental pollution indices were collected from Kellogg et al., (2000).

Environmental risks are constructed from exposure to pesticide runoff into surface water and pesticide leaching into groundwater (Kellogg et al., 2000). The assessment of risk was based on the extent to which the concentration of a specific pesticide out of approximately 200 pesticides exceeding a water quality threshold. The variable, HFR was defined as a risk to human health from exposure to pesticide runoff; the variable HFL was defined as a risk to human health from exposure to pesticide leaching; while the variables FFR and FFL were defined as a risk to fish life from exposure to pesticide runoff and leaching respectively. The data were obtained from Kellogg et al., (2000). Additional data collected by the authors included amount of pesticides/chemicals in ground water and air CO_2 and SO_2 as indications of air quality.

The data on prices, farm GDP and PGDP were available in various publications of ERS and state websites. The environmental data set, including data for FFL, FFR HHL and HHR, was available from 1973 to 1996, while data for export shares, CO2, pesticide and financial variables were available to 2004.

Table 1 presents estimated coefficients of the simultaneous system of export share and alternative pollution equations, while table 2 presents estimated coefficients of export share equation and each of the alternative pollution models. The estimated parameters appeared to be stable, indicating that overall fit of the models was good. In the estimated models, most coefficients were significantly different from zero and have right sign on the basis of economic theory. The results from the two different estimations presented in Tables 1 and 2 were similar. Thus, we mainly used the results presented in table 1 for analysis of the estimated results and interpretation/implications.

Export, Agricultural GDP and GDP Impacts on Pollution

Special attention was paid to separate the effects of the farm GDP and the PGDP on pollution measures. The findings suggested that the effect of the farm GDP was positive and significant at the 1.0% level, implying that pollution, as expressed by the included pollution indicators, increased with augmented agricultural production (table 1). However, the results seem to suggest that in increases in personal income (PDGP) are associated with reduction in environmental pollution as expressed by environmental risk factors. The finding is consistent with traditional view that increases in the level of development lead to clear environment. The estimated coefficients can be interpreted as elasticity since the models were estimated in a double-log functional form. The elasticities were, in absolute values, less than 1.00 for farm income, implying that pollution is not sensitive to changes in agricultural production (PGDP) in most cases. The results show that increases in export shares leads to increased pollution associated with chemical leaching into ground water threatening fish life, but reduces chemical runoff threatening human life and carbon level.

Environmental Risk Factors and Economic Variables Impacts on Agricultural Exports

Economic factors were included in the export share model to examine the state's production and export capacity on its export. The economic factors were statistically significant at the 5% level with positive signs, clearly indicating a strong impact on the export share. Increases in farm GDP and higher crop prices were clearly associated with higher levels of export shares. Total factor productivity and efficiency change were significant at the 5% level and had positive sign, indicating that efficiency improvements in the U.S. agricultural sector have spurred agricultural exports. Increases in crop prices were associated with increased export share as producers responded positively to higher export prices.

The environmental impact on exports is factor-specific. Most environmental variables are significant at the 5% level in the export equation. The impact of regulating pollution on exports varies by type of pollution. The results suggested that $CO_{2,}$ FFR, HFR and HFL weree statistically significant and positively associated with the state export share, while FFL was significant but negatively associated with the export share. This finding, in general, supported the hypothesis that regulating pollution leads to an increase in production costs and consequently causes a comparative disadvantage in exporting agricultural commodities. This result was consistent with previous studies (Pethig, 1976; McGuire, 1982; Baumol & Oates, 1988; Carraro & Siniscalco, 1992; Copeland & Taylor, 2003). States may lose a comparative advantage from significant amounts of costs incurred to state agricultural producers to conform with environmental regulations and/or to make product/output cost adjustments or resource relocation to meet it. However, most environment risk elasticities were less than 1.0, suggesting that export shares are not sensitive to changes in the environmental risk factors. Both operational and capital abatement were significant at the 5% level and had positive sign, indicating that reducing pollution levels was positively associated with export share in each state.

The NAFTA variable was not statistically significant for both export share and pollution equations, indicating that NAFTA has limited impacts on each state agricultural export shares and environment. However, the impacts of the EU on state export shares were strikingly significant for both state export share as well as environment risk equations, mainly FFL and HFL. The EU and expansion of its membership led to significantly reduced US agricultural export shares. This was due mainly to the EU internal agricultural policy and results of significant trade diversion. In general, the impact of the EU on environment was significant and led to reduce FFL and HFL.

CONCLUSIONS

The impact of environmental policy on international exports has received a great deal of attention among both academicians and policy makers. A system of export share and environmental risk models were estimated using the nonlinear least squares method described in RATS (2009). Also, a system of export share model and each of the environmental risk models were estimated using the same estimation method. The two methods provided nearly identical results. The results showed that economic variables, environmental factors, and relative prices were major determinants of agricultural export shares.

The estimated results suggested that higher farm GDP led to increased levels of pollution and export in most states in the U.S. Most environmental variables are positively related to state export of agricultural commodities, indicating that regulating pollution causes a comparative disadvantage in exporting agricultural commodities. The expansion of the EU had a negative effect on state export of agricultural commodities due mainly to trade diversion effects of the expansion. The EU diverts its imports from the US to its new member countries. NAFTA was not statistically significant in state export share equation mainly because Mexico and Canada are not major destinations of U.S. agricultural exports. The FTAs do not lead to environmental degradation as measured by the included environmental factors.

ENDNOTES

1. Theoretical model in Antweiler et al., (2001) included only capital/labor as factor abundance since there was little reason to believe that other endowment factors had an independent effect on either the demand

for a clean environment or the derived demand for pollution emissions. In the empirical model, Antweiler et al., (2001) included several factors abundance for sensitivity analysis.

2. Aggregated national level of import and summation of import and export trend is similar for 1975-2002. The simple correlation between export and import is 0.97 (Council of Economic Advisers, 2003).
3. Environmental pollution was considered as additional factor components following usual convention in environmental economics of treating pollution emissions as an input to production (i.e., Baumol & Oates, 1988).

REFERENCES

Antweiler, W., Trefler, D. (2002). Increasing returns and all that: A view from trade, *American Economic Review, 92*(1), 93-119.

Ball, V.E., Gollop, F.M., Kelly-Hawke, A. & Swinland, G.P. (1999). Patterns of state productivity growth in the U.S. farm sector: Linking state and aggregate models, *American Journal of Agricultural Economics, 81*(1), 164-79.

Ball, V.E., Butault, J-P., & Nehring, R. (2001). *U.S. Agriculture, 1960-96: A Multilateral Comparison of Total Factor Productivity*. Working Paper, Economic Research Service, US Department of Agriculture, ERS Technical Bulletin No. 1895. Washington, DC.

Baumol, W.J., & Oates, W.E. (1988). *The Theory of Environmental Policy* (2nd ed.), Cambridge: Cambridge University Press.

Carraro, C., & Siniscalco, D. (1992). The international dimension of environmental policy. *European Economic Review, 36*(2-3), 379-87.

Caves, D.W., Christensen, L.R., & Diewert, W.E. (1982a). Multilateral comparisons of output, input and productivity using superlative index numbers. *Economic Journal, 92*(365), 73-86.

Caves, D.W., Christensen, L.R., & Diewert, W.E. (1982b). The economic theory of index numbers and the measurement of input, output and productivity. *Econometrica, 50*(6), 1393-1414.

Copeland, B., & Scott, T. (2003). *Trade, Growth and the Environment, mimeo*. University of British Columbia.

Färe, R., Grosskopf, S., & Knox Lovell, C.A. (1985). *The Measurement of Efficiency of Production*. Boston: Kluwer-Nijhoff.

Färe, R., Grosskopf, S., Norris, M., & Zhang, Z. (1994). Productivity growth, technical progress, and efficiency change in industrialized countries. *American Economic Review, 84*(1), 66–83.

Grossman, G.M., & Helpman, E. (1991). Innovation and Growth in the Global Economy. Cambridge, Mass. and London: MIT Press.

Grossman, G.M., & Krueger, A.B. (1993). Environmental Impacts of a North American Free Trade Agreement in P. Garber (ed.): *The U.S.-Mexico Free Trade Agreement*. Cambridge, MA: MIT Press.

Harrigan, J. (1997). Technology, factor supplies, and international specialization: Estimating the neoclassical model. *American Economic Review*, *87*(4), 475-94.

Harris, M.N., Konya, L. & Matyas, L. (2002). Modeling the impact of environmental regulations on bilateral trade flows: OECD, 1990-96. *World Economy, 25*(3), 387-405.

Kellogg, R.L., Nehring, R., Grube, A., Goss, D.W., & Plotkin, S. (2000). *Environmental Indicators of Pesticide Leaching and Runoff from Farm Fields.* Working Paper, Natural Resources Conservation Service, U.S. Department of Agriculture, Washington, DC, USA.

Leamer, E.E., & Levinsohn, J. (1995). International Trade Theory: The Evidence. In Gene M. Grossman and Kenneth Rogoff (eds), *Handbook of International Economics, Vol. III*, 1339-96. Amsterdam: Elsevier.

Managi, S., & Karemera, D. (2005). Trade and environmental damage in U.S. agriculture. *The World Review of Science, Technology and Sustainable Development, 2*(2), 400-425. North Holland.

McGuire, M.C. (1982). Regulation, factor rewards, and international trade. *Journal of Public Economics, 17*(3), 335-354.

Paul, C.J.M., Ball,V.E., Felthoven, R.G., Grube, A., & Nehring, R.F. (2002). Effective costs and chemical use in united states agricultural production: Using the environment as a "free" input. *American Journal of Agricultural Economics, 84(*4), 902-15.

Pethig, R. (1976). Pollution, welfare, and environmental policy in the theory of comparative advantage. *Journal of Environmental Economics and Management, 2,* 160-169.

Redding, S. and Vera-Martin, M. (2001). Factor Endowments and Production in European Regions. mimeo, London School of Economics.

Van Beers, C., & Van den Bergh, J.C.J.M. (1997). An empirical multi-country analysis of the impact of environmental regulations on foreign trade flows. *Kyklos*, 50(1), 29-46.

United States Department of Agriculture (2008). *U.S. Agricultural Trade Boots Overall Economy*, FAU-124 Economic Research Service3/USDA.

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TABLE 1
NONLINEAR SYSTEM ESTIMATION OF EXPORT SHARE AND POLLUTION RISK MODELS UNDER ALTERNATIVE RISK MODEL SPECIFICATION

	Export Share	FFL	FFR	HFL	HFR	Carbon Dioxide
Constant	-7.995[a]	4.932[a]	-0.289	-1.544[b]	-0.778	-0.008
	(-7.13)	(4.82)	(-0.33)	(-2.01)	(-1.31)	(-0.04)
Export Share		0.227[a]	0.066[a]	-0.097[a]	-0.001	0.002
		(7.77)	(2.42)	(-4.27)	(-0.05)	(0.33)

Carbon Dioxide $_{t-1}$	0.062					0.992[a]
	(1.6)					(117.04)
FFL $_{t-1}$	-0.149[a]	0.905[a]				
	(-6.62)	(7.1)				
FFR $_{t-1}$	0.143[a]		0.938[a]			
	(9.07)		(75.49)			
HFL $_{t-1}$	0.121[a]			0.944[a]		
	(5.62)			(98.01)		
HFR $_{t-1}$	0.022				0.979[a]	
	(1.44)				(129.84)	
Capital Abatement	0.117 [a]	0.067[b]	0.016	0.016	0.012	-0.002
	(3.48)	(2.02)	(0.56)	(0.63)	(0.61)	(-0.22)
Operational Abatement	-0.192 [a]	-0.011	-0.031	0.005	-0.011	-0.001
	(-4.92)	(-0.3)	(-1.05)	(0.19)	(-0.55)	(-0.06)
Farm GDP	0.325[a]	-0.063 [c]	0.098 [a]	0.103[a]	0.031	-0.000
	(8.89)	(-1.94)	(3.21)	(4.14)	(1.52)	(-0.04)
GDP per Capita	0.014	-0.388[a]	-0.166[c]	-0.081	0.021	0.008
	(0.12)	(-3.96)	(-1.86)	(-01.07)	(0.36)	(0.35)
Crop Price	1.544[a]					
	(9.38)					
Live Stock Price	0.055					
	(0.35)					
Productivity	0.097[b]					
	(1.93)					
Effective Change	2.079[a]					
	(5.31)					
NAFTA	-0.128	-0.105	0.063	0.235a	0.067	0.067
	(-1.14)	(-0.96)	(0.66)	(2.81)	(1.03)	(1.03)
European Union	-0.379[a]	0.057	0.082[c]	-0.029	-0.013	-0.013
	(-7.36)	(1.15)	(1.89)	(-0.78)	(-0.45)	(-0.45)
Iterations Count	79	79	79	79	79	79
N	903	903	903	903	903	903
Objective Function Value	5418	5418	5418	5418	5418	5418
SEE	0.61	0.613	0.539	0.468	0.463	0.138

Numbers in ( ) are the t-statistics of the corresponding variables. a:indicates significance at 1%; b: indicates significance at 5%; and c: indicates significance at 10%

TABLE 2
PAIRWISE NONLINEAR SYSTEM ESTIMATION OF EXPORT SHARE MODEL AND EACH POLLUTION RISK MODEL UNDER ALTERNATIVE RISK MODEL SPECIFICATION

	Export Share	FFL	Export Share	FFR	Export Share	HFL	Export Share	HFR	Export Share	Carbon Dioxide
Constant	-8.089	4.637a	-8.079a	-0.978	-7.88a	-1.495c	-7.967a	-1.442b	-7.843a	0.048
	(-7.15)	(4.56)	(-7.09)	(-1.06)	(-6.82)	(-1.93)	(-6.85)	(-2.24)	(-6.71)	(0.22)

Export Share		0.194a		0.011		-0.097a		-0.038c		0.006
		(6.63)		(0.38)		(-4.32)		(-1.94)		(0.9)
FFL $_{t-1}$	-0.135a	0.913a	-0.1a		-0.101a		-0.092a		-0.092a	
	(-5.82)	(70.9)	(-4.42)		(-4.43)		(-3.99)		(-3.95)	
FFR $_{t-1}$	0.14a		0.134a	0.955a	0.139a		0.133a		0.137a	
	(8.61)		(8.32)	(71.94)	(8.64)		(8.23)		(8.46)	
HFL $_{t-1}$	0.104a		0.066a			0.064a	0.953a		0.057b	
	(4.68)		(2.98)			(2.88)	(96.24)		(2.51)	
HFR $_{t-1}$	0.031b		0.037b			0.033b		0.989a	0.038b	
	(1.98)		(2.33)			(2.05)		(118.52)	(2.36)	
Carbon Dioxide$_{t-1}$	0.049		0.045			0.048			0.051	0.992a
	(1.23)		(1.1)			(1.17)			(1.22)	(119.31)
GDP per Capita	0.04	-0.383a	0.033	-0.134	0.019	-0.071	0.023	0.058	0.Q18	0.007
	(0.34)	(-3.94)	(0.28)	(-1.43)	(0.16)	(-0.93)	(0.19)	(0.89)	(0.15)	(0.31)
Farm GDP	0.316a	-0.052	0.318a	O.I13a	0.312a	0.098a	0.315a	0.047b	0.31a	-0.002
	(8.55)	(-1.59)	(8.53)	(3.5)	(8.3)	(3.93)	(8.31)	(2.1)	(8.14)	(-0.36)
Crop Price	1.589a		1.609a			1.597a			1.569a	
	(9.33)		(9.35)			(9.22)			(8.9)	
Live Stock Price	-0.05		-0.128			-0.085			-0.076	
	(-0.31)		(-0.78)			(-0.51)			(-0.45)	
Productivity	0.073		0.088c			0.109b			0.083	
	(1.4)		(1.67)			(2.05)			(1.54)	
Operational Abatement	-0.18a	-0.02	-0.165a	-0.041	-0.167a	0	-0.158a	-0.013	-0.167a	0
	(-4.58)	(-0.57)	(-4.19)	(-1.31)	(-4.17)	(-0.01)	(-3.93)	(-0.59)	(-4.14)	(0.01)
Capital Abatement	0.118a	0.072b	0.119a	0.028	0.119a	0.018	0.117a	0.015	0.122a	-0.002
	(3.51)	(2.18)	(3.55)	(0.9)	(3.49)	(0.7)	(3.42)	(0.7)	(3.56)	(-0.29)
Effective Change	1.973a		2.089a			2.01a			1.984a	
	(4.86)		(5.05)			(4.83)			(4.67)	
NAFTA	-0.117	-0.1	-0.08	0.044	-0.086	0.242a	-0.072	0.098	-0.069	0.012
	(-1.05)	(-0.92)	(-0.72)	(0.45)	(-0.77)	(2.93)	(-0.64)	(1.41)	(-0.61)	(0.52)
EU	-0.375a	0.053	-0.378a	0.052	-0.363a	-0.038	-0.366a	-0.051	-0.361a	-0.001
	(-7.25)	(1.08)	(-7.31)	(1.15)	(-6.91)	(-1.02)	(-6.94)	(-1.6)	(-6.82)	(-0.12)
Iteration count	57	57	77	77	52	52	52	52	43	43
N	903	903	914	914	917	917	919	919	920	920
Objective function value	1806	1806	1828	1828	1834	1834	1838	1838	1840	1840
Standard Error of Estimate	0.609	0.608	0.611	0.571	0.62	0.473	0.623	0.398	0.626	0.137

Numbers in parentheses are the t-statistics of the corresponding variables.
a: Indicates significance at 1%;b:indicates significance at 5%; and c: indicates significance at10%.