Impacts of Regulating Greenhouse Gas Emissions on Livestock Trade Flows

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Abstract: The policies that regulate greenhouse gas emissions would provide a significant burden to emission industries as well as final consumers, which can lead to a strong influence on international trade flows of commodities. This study examines the impact of regulating greenhouse gas emissions on livestock trade flows using a commodity specific gravity model approach. This study finds that regulating greenhouse gas emissions has a negative effect on livestock trade flows from countries restricting greenhouse gas emissions to unrestricting countries, from restricting to restricting countries, and from unrestricting to restricting countries.

Key words: gravity model, livestock, regulating greenhouse gas emission, trade

1. Introduction

The Kyoto Protocol, the first international agreement on greenhouse gas (GHG) emissions, entered into force on February 2005. As of November 2009, 187 parties have ratified the protocol to reduce their collective GHG emissions by 5.2% from the 1990 level by the end of 2012 (UNFCCC, 2009). Under the Kyoto Protocol, however, only 37 industrialized countries, known as Annex I parties, have a binding commitment to reduce GHG produced by them, while non-Annex I parties do not have a binding commitment by 2012. The governments of developed countries have been considered two different policies to regulate GHG emissions: carbon tax or cap-and-trade scheme. Both carbon tax and cap-and-trade give polluters a financial incentive to reduce their GHG emissions. However, these options could provide a significant burden to emission industries as well as final consumers. According to Olivier et al (2005), 26 percent of GHG emissions were derived from energy supply (electricity and heat generation), about 19 percent from industry, 14 percent from agriculture in 2004 (figure 1). Hence, regulating GHG emissions may cause increase in prices of commodities produced by these sectors, which leads to an increase in production costs of processing companies that use the commodities as input factors. Processing companies then may reduce their production or raise the prices of processed goods to diminish their burden. This leads to an increase in the prices of consumer products, and affects trade of the products. In addition, countries restricting GHG emissions could have a comparative disadvantage over unrestricting countries in producing pollution intensive products, which alters trade flows of the products between the countries. The livestock industry is a good example which is influenced by regulation of GHG emissions since increases in the prices of energy and fertilizer, transport cost, and waste management cost simultaneously affect livestock production costs. An increase in production cost of the livestock industry would lead to increase in the prices of livestock products and also lead to decrease in profit margin of the industry.

The objective of this study is to examine the impact of regulating GHG emissions on trade flows of livestock products using a commodity-specific gravity model. Several studies have used the gravity model to examine bilateral trade flows between country pairs. Formal theoretical foundations of the model have been provided in Anderson (1979) and Bergstrand (1985, 1989). The model has been used to study the ex post effects of Free Trade Agreement (FTA) in many studies (Tinbergen 1962; Aitken 1973; Abrams 1980; Brada and Mendez 1985; Bergstrand 1985; Frankel et al. 1995; Frankel 1997; Soloaga and Winters 2001; Carrere 2006; Baier and Bergstrand 2007). These studies have used typical gravity model which analyze total trade flows of aggregate goods between country pairs rather than a single commodity trade flows. Koo and Karemera (1991) and Koo et al. (1994) have modified the typical gravity model for aggregate goods to analyze a single commodity trade flow. In addition, Dascal et al. (2002) analyze the main factors affecting the trade flows of wine in the EU using a gravity model approach. However, there are few studies that examine the impact of regulating GHG gas emissions on trade flows, and as far as we know, this is the first study to do so.

The rest of the article is distributed into five main sections. The commodity-specific gravity model is developed in Section 2. The data and empirical procedure have been discussed in Section 3 and Section 4, respectively. In section 5, the empirical results have been reported. Finally, in Section 6, conclusions have been drawn.

2. Commodity-specific gravity model

Gravity models have been used to describe bilateral trade flows between country pairs. The traditional gravity model contains the following variable components: (1)

economic factors affecting trade flows in the origin countries, (2) economic factors affecting trade flows in the destination countries, and (3) natural or artificial factors enhancing or restricting trade flows. Thus, the typical gravity model in international trade can be defined as:

$$PX_{ij} = \beta_0 (Y_i)^{\beta_1} (Y_j)^{\beta_2} (D_{ij})^{\beta_3} (A_{ij})^{\beta_4} \varepsilon_{ij} \qquad (1)$$

where PX_{ij} represents bilateral trade flows from country *i* to country *j*, Y_i (Y_j) indicates income of country *i* (*j*), D_{ij} represents the distance from the economic center of *i* to that of *j*, A_{ij} is any other factor(s) either aiding or resisting trade between *i* and *j*, and u_{ij} is a log-normally distributed error term with zero mean. The income of exporting country represents the country's production capacity and that of importing country represents the country's purchasing power. Hence, it is expected that trade flows are positively related to the exporting and importing countries' income. The distance between countries, which is trade barrier, should be negatively related to trade flows. Other factors such as common border, common language, or land locked are usually included in the model. It is hypothesized that dummy variables for common border and common language are positively related to trade flows while land locked dummy variable is negatively related to trade flows. Dummy variables representing regional and bilateral free trade agreements (FTA) are usually included in the model under an assumption that FTAs enhance trade among member countries. In addition, the globalization index for exporting and importing countries, which represents trade liberalization of those countries, could be included in the model under an assumption that globalization enhances trade flows between countries.

The commodity specific-gravity model for livestock trade can be derived from equation (1) by incorporating the unique characteristics and policies associated with trade flows of the specific commodity in exporting and importing countries. The income of exporting country is replaced with the country's agricultural income to represent the country's overall production capacity of agricultural commodities. To measure livestock production, the model includes the amount of livestock production in exporting and importing countries, which are expected to be positively and negatively related to trade flows, respectively. Animal diseases can be a main factor of import restriction in livestock trade. For instance, from 2004 through 2006, many countries completely banned import of beef from the U.S. because of Bovine Spongiform Encephalopathy (BSE). Hence, a dummy variable of animal disease is introduced to account for livestock trade flows from countries infected with the disease.

To examine the effect of regulating GHG emission on trade of livestock products, four dummy variables are included in the model. They represent trade flows of livestock products (1) from a country restricting GHG emissions to a country unrestricting GHG emission, (2) from a restricting country to a restricting country, (3) from an unrestricting to a restricting country, and (4) from an unrestricting country to an unrestricting country. The first dummy variable is hypothesized to be negative since restricting GHG emissions in an exporting country increases the production costs of livestock products, which lead to increase in the price of livestock products and reduce exports to its trading partners. The second dummy variable is also expected to be negatively related to trade flows of livestock because an increase in the prices of livestock products in both exporting and importing countries could decrease demand for livestock products in the countries, which leads to decrease in total trade flow of livestock products between the countries. The third dummy variable would be either positively or negatively related to trade flow. Trade flows of livestock could increase mainly because the prices of livestock products in exporting countries are lower than importing countries. On the other hand, trade volume would decrease because of decrease in domestic demand for livestock products resulting from increase in the prices of the products, or because of trade restriction on livestock products imported from countries unrestricting GHG emissions. The last dummy variable is hypothesized to be positive since the unrestricting import countries would import more livestock from other unrestricting countries instead of import from restricting countries. The empirical gravity model for livestock trade then can be specified as follows:

$$PX_{ij} = \beta_0 (AY_i)^{\beta_1} (Y_j)^{\beta_2} (D_{ij})^{\beta_3} (Q_i)^{\beta_4} (Q_j)^{\beta_5} (G_i)^{\beta_6} (G_j)^{\beta_7} e^{\beta_8 CB_{ij}} e^{\beta_9 CL_{ij}} e^{\beta_{10} LL_i} e^{\beta_{11} FTA_{ij}} e^{\beta_{12} BSE_i} e^{\beta_{13} RU_{ij}} e^{\beta_{14} RR_{ij}} e^{\beta_{15} UR_{ij}} e^{\beta_{16} UU_{ij}} \varepsilon_{ij} \quad (2)$$

where AY_i is agricultural income in country *i*, Q_i (Q_j) is the amount of livestock production in country *i* (*j*), G_i (G_j) is globalization index in country *i* (*j*), CB_{ij} is a dummy variable for common border ($CB_{ij} = 1$ if *i* and *j* share a common land border and 0 otherwise), CL_{ij} is a dummy variable for common language ($CL_{ij} = 1$ if *i* and *j* share a common language and 0 otherwise), LL_i (LL_j) is a dummy variable for landlocked (LL_i (LL_j) if *i* and/or *j* is landlocked and 0 otherwise), FTA_{ij} is a dummy variable for FTA

($FTA_{ij} = 1$ if *i* and *j* belong to the same FTA and 0 otherwise), BSE_i is a dummy variable for BSE ($BSE_i = 1$ if *i* is infected with BSE and 0 otherwise), RU_{ij}, RR_{ij}, UR_{ij} and UU_{ij} are dummy variables for regulation of GHG emissions in *i* and *j* ($RU_{ij} = 1$ if *i* regulates GHG emission and *j* does not regulate GHG emission; $RR_{ij} = 1$ if *i* and *j* regulate GHG emission; $UR_{ij} = 1$ if *i* does not regulate GHG emission and *j* regulate GHG emission; $UU_{ij} = 1$ if *i* and *j* do not regulate GHG emission and 0 otherwise) and ε_{ij} is assumed to be a log-normally distributed error term. It is note that the last six dummy variables are not in force for every year and country during the period of study. Some values are zero at times. Thus, those variables are coded into qualitative variables to limit those variations.

3. Data

The model is estimated with data for 30 OECD member countries and 10 OECD accession candidate and enhanced engagement countries over the period 1999 through 2007. Nominal bilateral trade flows for meat and edible meat offal are from UN COMTRADE (2009). Since import data are generally more reliable than export data (Nicita and Olarreaga, 2001), this study uses mutual imports to calculate overall livestock trade between each country pair (zero trade flows are excluded). For the income of importing country and the agricultural income of exporting countries, gross domestic products (GDP) and agricultural GDP, respectively, are obtained from the World Development Indicator (WDI) database complied by the World Bank (2009). These data are scaled by GDP deflators to create real GDPs for the panel analysis. The amount of livestock production in exporting and importing countries are from the Earth Trends database compiled by World Resource Institute (WRI, 2009). The ratio of the value of total trade to real GDP is used a proxy for globalization index and is obtained from the Penn World Table (2009). Bilateral distances are compiled using the Central Intelligence Agency (CIA, 2009) World Factbook for longitudes and latitudes of economic centers to calculate the great circle distances. Data on common borders, languages and landlocked countries are also obtained from the World Factbook. Data on BSE are obtained from the animal diseases data compiled by the World Organisation for Animal Health (OIE, 2009). The FTA dummy variable is calculated using a table in Baier and Bergstrand (2007) and European Union (EU) website (table 1). Dummy variables, RU_{ij}, RR_{ij}, UR_{ij} and UU_{ij}, are compiled using Kyoto Protocol Status of Ratification by United Nations Framework Convention on Climate Change (UNFCCC, 2009). Table 2 shows countries restricting and unrestricting GHG emissions.

4. Empirical procedure

Our panel estimation is based on fixed effect model rather than random effect model for two reasons. First, since this study examines livestock trade flows among OECD countries, we do not interested in the estimation of trade flows between a randomly drawn sample of countries but between an ex ante predetermined selection of nations. Therefore, in this case, the fixed effect model would be more appropriate than random effect model. Second, Egger (2000) empirically finds that a fixed effect gravity model is the proper econometric specification of a gravity model in most applications.

To examine the efficiency of the model, we conduct *F*-tests for fixed effects and White tests for heteroskedasticity. Table 3 provides tests results for fixed effects and heteroskedasticity in the model. The tests results indicate that the null hypothesis of no fixed effects is rejected for all cases, which mean that the model should include time and bilateral fixed effects. The White test for heteroskedasticity indicates that there is little evidence that error terms have serious heteroskedasticity within cross-section units.

Equation (2) in time series and cross-section form, then, can be expressed as:

$$\ln PX_{ijt} = \overline{\beta_0} + \sum_{k=1}^{16} \beta_k \ln Z_{kt} + \psi_t + \phi_{ij} + \varepsilon_{ijt} \qquad (3)$$

where PX_{ijt} is trade observation from *i* to *j* at time *t*, Z_{kt} is a vector of corresponding trade determinants, ϕ_{ij} is the trade fixed effect associated with the country pair *i* and *j*, ψ_t is the time fixed effect specific to a particular year, and ε_{ijt} is an error term. Equation (3) is estimated under three assumptions: (1) the time effects ($\psi\downarrow t$) are equal to zero for all years, (2) the bilateral trade effects ($\phi\downarrow ij$) are equal to zero for all cross-section units, and (3) all trade effects vary over both time series and cross-section units through the intercept term.

5. Empirical results

Table 4 shows the empirical results of estimating gravity equation (3) using a panel real livestock trade data. Most estimated parameters have the expected signs and are statistically significant. The model with bilateral and time fixed effect is used in the analysis since the model is preferred on the basis of the traditional measures of goodness of fit in that it provides the highest *R*-squared. However, estimated coefficients for distance (D_{ij}), common border (CB_{ij}) and language (CL_{ij}), landlocked (LL_{ij}) and FTA (FTA_{ij}) are not provided in the model with cross-section fixed effect since they are constant over time period. Therefore, the model with time fixed effect is used to determine signs of estimated parameters for these variables.

As we mentioned in section 2, real GDP for the farm sector of exporting country is used for overall production capacity in agricultural sector while real GDP of importing country is used to represent consumers' purchasing power. Moreover, the amount of livestock production in exporting and importing countries are used to represent a measure of livestock production in these countries. The estimated coefficients on exporting country's agricultural income and importing country's income are positive as expected and statistically significant at the 5% level. This indicates that livestock trade flows increase as agricultural production capacity of exporting country and consumers' purchasing power of importing country increase. On the other hand, the estimated coefficient on exporter's livestock production is positive as hypothesized but does not significantly differ from zero, while that on importer's livestock production is negative as expected and significantly differ from zero at the 5% level. This implies that direction of livestock trade flows is more largely affected by livestock production in importing country relative to that in exporting country.

For the globalization index which is used as a proxy of trade liberalization, we hypothesize that livestock trade flow increases as a country is more trade liberalized. The estimated coefficient on trade liberalization of exporting country is positive as hypothesized and statistically significant at the 5% level, while that of importing country is not significant. Globalization tends to provide opportunities to increase exports and stimulate competition among exporting countries.

Geographic factors such as a longer distance between trade partners and countries being landlocked may impair trade. On the other hand, other factors such as countries sharing a common border and language, and joining same FTA may enhance trade among countries. The estimated coefficients on distance and landlocked variables are negative as expected and significant at the 5% level. This indicates that transportation costs increase as distance between trading partners is getting longer, or one (or both) of trading partners is landlocked, and this leads to decrease in trade volume. The dummy variables for common border and language, and FTA are statistically significant at the 5% level. The positive coefficients of these variables imply that trade volume increases among countries sharing common border and language and joining same FTA. In addition, estimated coefficient of BSE dummy variable is negative statistically significant at the 5% level, which means BSE weakens bilateral trade flows of livestock products.

A dummy variable representing the effect of regulating GHG emission on livestock trade from countries restricting GHG emissions to countries unrestricting GHG emissions is negative as hypothesized and significant at the 5% level. As indicated earlier, restricting GHG emissions increases the price of livestock products in exporting countries, and this leads to a decrease in trade volume of livestock products between the countries. The estimated coefficient on the effect of GHG emission on trade flows of livestock products from restricting countries to restricting countries is also statistically significant at the 5% level. The negative coefficient of this variable implies that an increase in the prices of livestock products in both exporting and importing countries decreases demand for livestock products in the countries, which leads to a decrease in trade flows between the countries. The effect of regulating GHG emissions on livestock trade flows from unrestricting countries to restricting countries is negative and statistically significant at the 5% level. This indicates that trade volume of livestock products decrease because of decrease in domestic demand for livestock products resulting from increase in the prices of the products or trade restriction on livestock products imported from unrestricting countries. The estimated dummy variable for the effect of GHG emissions on trade flows from unrestricting countries to unrestricting countries has negative sign which is different from assumption but does not statistically differ from zero. The result of joint test shows that the null hypothesis of no impact of regulating GHG emissions on trade flows of livestock products is rejected at the 5% significant level (table 5). This indicates that the regulation policy of GHG emission has significant impacts on international trade of livestock products.

6. Concluding remarks

Since the Kyoto Protocol, the first international agreement on GHG emissions, entered into force on February 2005 as of November 2009, 187 parties have ratified the protocol to reduce their collective GHG emissions. The governments of those parties have been considered two different policies – carbon tax or cap-and-trade scheme – to regulate GHG emissions. However, these policies could provide a significant burden to emission industries as well as consumers. In addition, these options should have strong influence on international trade flows. Therefore, this study examines the impact of regulating GHG emissions on livestock trade flows using a commodity specific gravity approach.

We find that most of variables using in the model are statistically significant and have expected signs. On the export side, income in agricultural sector and trade liberalization are positively related to trade flows of livestock products. The livestock production in exporting country does not influence trade flows. On the import side, income is positively related to livestock trade flows, while the amount of livestock production is negatively related. The trade liberalization in importing country does not have influence on livestock trade flows. Common border and language, and FTA stimulate livestock trade flows, while distance, landlocked, and BSE weaken livestock trade flows.

Additionally, we find that the regulation policy of GHG emission has significant effect on international trade of livestock products. Regulation of GHG emissions decreases trade volume of livestock products from countries restricting GHG emissions to unrestricting countries, from restricting to restricting countries, and from unrestricting to restricting countries. An important implication of our finding is that the regulation of GHG emission would have negative impacts on livestock products trade flows under the current circumstance that only industrialized countries regulate GHG emissions.

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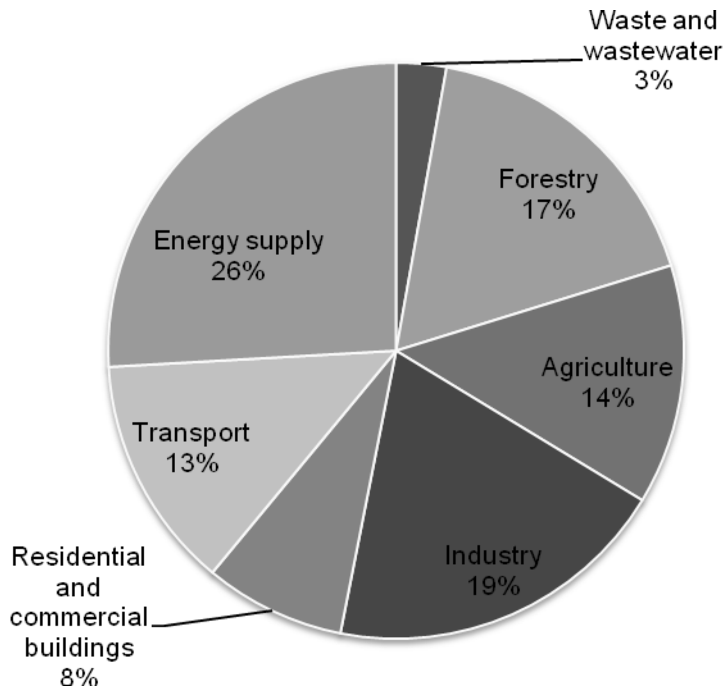

Fig. 1. GHG emissions by sector in 2004. *Source: Olivier et al. 2005, 2006*

Table 1. Free Trade Agreements Included in the Study.

European Union (1958): Belgium-Luxembourg, France, Italy, Germany, Netherlands, Denmark (1973), Ireland (1973), United Kingdom (1973), Greece (1981), Portugal (1986), Spain (1986), Austria (1995), Finland (1995), Sweden (1995), Czech (2004), Estonia (2004), Hungary (2004), Poland (2004), Slovakia (2004), Slovenia (2004)

European Free Trade Association (1960): Norway, Switzerland

Australia-New Zealand Closer Economic Relations (1983)

US-Israel (1985)

US-Canada (1989)

EFTA-Israel (1993)

EU-EFTA Agreement (1994)

Central Europe Free Trade Agreement (1993): Hungary, Poland (1997 to 2004)

EFTA-Hungary (1993)

EFTA-Poland (1993)

EU-Hungary (1994 to 2004)

EU-Poland (1994 to 2004)

North America Free Trade Agreement, or NAFTA (1994): Canada, Mexico, United States

Canada-Chile (1997)

Canada-Israel (1997)

Hungary-Turkey (1998)

Table 1. (Continued)

Hungary-Israel (1998)
Israel-Turkey (1998)
Poland-Israel (1998)
Mexico-Chile (1999)
EU-Israel Agreement (2000)
EU-Mexico (2000)
Poland-Turkey (2000)
Mexico-Israel (2000)

Note: Countries listed in agreements only include those in our sample of 40 countries. Years in parentheses denote year of entry, except where noted otherwise.
Sources: Baier and Bergstrand (2007) and EU (2009) available at http://europa.eu/abc/european_countries/eu_members/slovenia/index_en.htm.

Table 2. Lists of Countries Restricting and Unrestricting GHG emissions.

GHG emissions	Countries
Restrict	Austria, Belgium, Canada, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Luxembourg, Netherlands, New Zealand, Norway, Poland, Portugal, Russia, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, United Kingdom
Unrestrict	Australia, Brazil, Chile, China, Israel, India, Indonesia, South Africa, Korea, Mexico, Turkey, United States

Note: Countries listed only include those in our sample of 40 countries.
Source: UNFCCC, 2009

Table 3. Tests results for fixed effects and heteroskedasticity in the gravity model.

Hypothesis	Test statistic	With bilateral fixed effects	With time fixed effects	With bilateral and time fixed effects
No fixed effects	*F*	45.82*	1.95*	45.45*
Homoskedasticity	χ^2	1.60	4.00	1.07

Note: An asterisk (*) indicates significance at 5% level.

Table 4. Estimated coefficients of the gravity model.

Variable	With bilateral fixed effects		With time fixed effects		With bilateral and time fixed effects	
$\ln FY_i$	1.06	(8.61)*	0.38	(8.15)*	1.05	(7.87)*
$\ln Y_j$	0.60	(4.58)*	0.19	(12.74)*	0.40	(2.57)*
lnD_{ij}			-0.68	(-10.89)*		
lnQ_i	0.01	(0.62)	0.27	(11.10)*	0.01	(0.24)
lnQ_j	-0.02	(-1.75)**	0.01	(0.27)	-0.02	(-2.06)*
lnG_i	1.55	(7.79)*	0.78	(6.76)*	1.66	(7.68)*
lnG_j	-0.25	(-1.30)	-0.18	(-1.77)**	-0.37	(-1.53)
CB_{ij}			1.48	(11.55)*		
CL_{ij}			0.55	(4.60)*		
LL_{ij}			-0.86	(-9.41)*		
FTA_{ij}			0.42	(4.96)*		
BSE_{ij}	-0.58	(-4.98)*	-0.67	(-2.72)*	-0.67	(-5.66)*
RU_{ij}	-0.22	(-1.96)**	-1.87	(-2.70)*	-1.22	(-3.54)*
RR_{ij}	0.18	(3.11)*	-1.14	(-1.61)	-0.90	(-2.54)*
UR_{ij}	-0.37	(-4.50)*	-2.20	(-3.04)*	-1.45	(-4.04)*
UU_{ij}	0.48	(2.56)*	0.48	(0.61)	-0.58	(-1.47)
R^2	0.887		0.244		0.888	

Note: bilateral and time effects are not reported. *t*-statistics are in parentheses. Asterisks * and ** indicate significance at 5% and 10%, respectively.

Table 5. Results of Joint Test.

Hypothesis	Test Statistics	With bilateral fixed effects	With time fixed effects	With bilateral and time fixed effects
$\beta_{13}, \beta_{14}, \beta_{15}$ and $\beta_{16} = 0$	χ^2	61.07*	79.77*	70.12*

Note: An asterisk (*) indicates significance at 5%.