GREENHOUSE GAS POLICIES AND THE INTERNATIONAL COMPETITIVENESS OF THE HOG INDUSTRY

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1.0 Introduction

In the past 15 years, the potential for climate change induced by the accumulation of GHG has become an environmental concern of global significance. In 1990 many countries became part of the United Nations Framework Covention on Climate Change which as primary goal of the reducing global greenhouse gas emissions. The Kyoto Accord, signed in December 1997, was an proposed agreement for signifcant reduction in greenhouse gas emissions for the period 2008 - 2012. Although this agreement does not come into effect until countries with 55% of emission have ratified the agreement, there indications that it may be ratified in 2001.

The objective of this paper is to examine whether greenhouse gas reduction is potentially an important issue for livestock trade.

The remainder of the paper begins with brief background information on the climate change agreements and the greenhouse gas emissions from agricultural production with specific estimates for hogs. This information is used to calculate the approximate size of a Pigovian (no pun intended) tax on hog production. In order assess the potential trade impacts a simple six region model is developed and used to simulate the impact of Pigovian taxes with different international participation rates. The paper is concluded with a discussion of the policy implication and a call to arms for more greenhouse gas abatement related trade research.

2.0 Background

2.1 Climate Change Agreements

In 1992, in Rio de Janeiro, many countries agreed in principle to stabilize Greenhouse Gas emissions *creating* the United Nations Framework Convention on Climate Change (UNFCCC, 1997). Despite the agreement, emissions continued to grow. In 1997, the parties to the UNFCCC met again in Kyoto and made further commitments to limit and reduce GHG emissions. In the Kyoto Accord, the developed countries of the world agreed to specific emission targets to be achieved during the 2008–2012 period, relative to a 1990 baseline. In this Accord, Canada committed to a reduction in GHG emissions to a level six percent less than 1990 emissions, the US agreed to a seven percent reduction and the EU agreed to an eight percent reduction (UNFCCC). These reduction targets are much more significant than the absolute percentages would suggest, given the growth in post 1990 emissions. In Canada, the 6 percent Kyoto reduction target represents a 25 percent reduction below business as usual projections.

At this point, the Kyoto Accord is very much an incomplete agreement. First, the developing countries of the world, including the very populous India and China, are not signatories to the accord. Many features are vaguely described such as "Joint Implementation" and "Clean Development Mechanisms". There are emission trading mechanisms that have yet to be defined. Many definitions and measurements have yet to be agreed upon, such as the definition of a managed versus an unmanaged forest. While the decomposition of organic matter in agricultural soils has been defined as a source of CO_2 in the Accord, soils are not included as a sink. A sink is a process whereby atmospheric CO_2 is sequestered by plants and converted into organic matter where it is stored in the soil. Similarly, the use of agricultural and forest crops in building products are not yet included as sinks. There are no agreed upon penalties for non-compliance within the Accord, which has important implications for trade.

Despite the current incompleteness of the Accord, its greatest limitation is that it has yet to be ratified to become a binding agreement. The Accord does not "come into effect" until countries that make up 55 percent of the GHG emissions have ratified the agreement (UNFCCC). In other words, if Canada were to ratify the agreement by having Parliament commit to the 6 percent reduction, this commitment would not be binding until enough other countries did likewise, bringing the Accord into effect. This ratification process has introduced a great deal of uncertainty for the signatories because there is a good chance the Accord will not have sufficient ratification to come into effect.

At this point, the United States Congress has not given Presidential Fast Track Approval to negotiate a climate change agreement. Without this approval, the US Congress would be able to vote on and accept particular parts of the Accord while rejecting other parts. As has been shown previously with trade agreements under these conditions, other countries will be very reluctant to ratify the Accord. Furthermore, given that the US makes up 35 percent of total GHG emissions, the US ratification is pivotal to the overall agreement.

2.2Agricultural GHG Emissions

The agricultural sector is a significant global GHG emitter. Each country has different levels of emissions depending on the agricultural systems employed. The agricultural emissions from Canada are provided below to give some idea of the magnitude and the sources of GHG emissions in agriculture.

The estimates of 1991 GHG emissions for Canada and those associated with Canadian agriculture are shown in Table 1. There are several interesting points in this table. First, direct and indirect emissions from agriculture make up 14 percent of the total Canadian GHG emissions, thus agriculture is nationally important. Nitrous oxide (N_2O) and methane (CH_4) dominate direct emissions from agriculture, while carbon dioxide (CO_2), N_2O and CH_4 are all significant indirect emissions. Although non-agricultural Canadian emissions are dominated by CO_2, overall agricultural emissions have a large component of N_2O and CH_4.

Table 1: Canadian Total and Agricultural Anthropogenic GHG Emissions in 1991

	All Sources	Direct Ag.	Indirect Ag.	Total Ag.	% Ag.
	Million tonnes of CO_2 Equivalent				
Carbon dioxide	452	5	15	20	4%
Methane	70	20	9	29	41%
Nitrous oxide	51	24	10	34	66%
Total	575	49	34	83	14%

Source: Jansen et al., 1999

Nitrous oxide (N_2O) is the GHG producing the largest net CO_2 equivalent emissions from agriculture (Jansen et al.). About one-half of agricultural N_2O emissions are created primarily from the nitrogen cycle occurring within agricultural soils. During the processes of nitrification, (the conversion of NH_4^+ to NO_3^- by soil bacteria) and denitrification (the conversion of NO_3^- to N_2), N_2O is released into the atmosphere. The amount of nitrogen released is dependent upon many factors, including moisture levels, carbon and nitrogen availability, and temperature. This

N_2O release occurs with both natural forms of nitrogen, i.e. from manure and legumes; and from manufactured forms of nitrogen, i.e. nitrogen fertilizer. The release of nitrous oxide tends to be very episodic with large quantities released in very short periods. The other sources of N_2O emissions are from the decomposition of manure during storage and application and from its release during the manufacture of fertilizer and other agricultural inputs. The estimates of the emissions of nitrous oxide from Canadian agriculture are very preliminary and will be the focus of study and measurement for the next several years.

Methane is the other important GHG in agriculture. Methane is released during anaerobic decomposition of organic matter. By far the largest source of CH_4 emissions within agriculture is from enteric fermentation within the rumen of beef and dairy cattle, accounting for 80 percent of agricultural methane emissions. Most of the remaining 20 percent of methane emissions comes from the decomposition of all forms of livestock and poultry manures during storage and handling. This is the major source of GHG emission from hog production.

2.3 Estimating economic costs GHG emissions for hog production

The production of hogs involves the emission of methane and nitrous oxide. The methane emissions come primarily from the anaerobic decomposition of manure during the storage and spreading of the manure. The majority of nitrous oxide emissions, (which is less than 1/2 of the total) are from the nitrogen in the manure once applied to the field. These nitrous oxide emissions cannot be fully attributed to hog production because other forms of nitrogen would likely be applied to these same soils in the absence of hog manure. However, the high levels of manure application, along with water and carbon in the liquid manure slurry, make nitrous oxide emissions higher than would be the case with other nitrogen forms.

The estimates of GHG emissions from hog production are shown in Table 2. The methane and nitrous oxide emissions are shown in the second and third columns and are converted into carbon dioxide equivalents in the fourth column. The final column has valued these emissions in terms of abatement costs. The abatement cost of $20 per tonne represents the conservative end of the range of marginal costs required to meet the Kyoto commitments within Canadian economy. One can think of the cost as the price for a one tonne emission permit in a carbon trading system. If emissions per hog are in fixed proportion the cost per hog would equal the optimal Pigovian tax on hog production. The actual value of the abatement costs will largely be determined by how aggressive the governments are with respect to GHG reduction and the technologies that will become available once appropriate incentives have been put in place. The purpose is to show the order of magnitude of this external environmental cost relative to the market costs of producing pork. As is shown in the last row of Table 2 this cost translate into $50 per tonne of pork meat, or about 6% of the current price. These are not inconsequential costs and therefore could have important production and trade effects depending on how they are applied internationally.

Table 2: Greenhouse Gas Emissions from Hog Production – Canada -1999

Units	Methane kg/yr.	Nitrous Oxide kg/yr.	Carbon Dioxide Equiv. kg/yr.	Cost @ $20/t CO_2
Per head of inventory	11.5	0.439	378	$7.55
per head sold	6.8	0.26	223	$4.46
Per tonne of carcass wt.	81.8	3.1	2690	$53.74

Source: Jansen 2000, and authors calculations

[a] The nitrous oxide and the methane are expressed in 100 year global warming potential as prescribed by the Intergovernmental Panel on Climate Change which 21 times for methane and 310 times for nitrous oxide.
[b] The estimated external abatement costs of CO2 reduction vary a great deal $20 US per tonne is conservative estimate with current technologies.
[c] These coefficients are the same used to calculate Canadian GHG emissions and include direct as well as indirect emissions August 2000 (Jansen, 2000)
[d] This calculation is based on the 1999 Canadian (AFFC) marketings to inventory ratio
[e] This is based on a carcass weight of 83 kg.

3.0 Description of the Trade Simulation Model

For the purposes of modelling the impact of GHG policies on trade a simple a six region static trade model is used to examine impacts in a four year (2004) and a nine year (2009) timeframe. The six regions modelled are Canada, China, EU, Japan, USA and the Rest of World (ROW).

The impacts of environmental policy scenarios are modelled relative to the 2000, Food and Agricultural Policy Research Institute (FAPRI), World Outlook 2000 estimates for the years 2004 and 2009. These quantities used to construct the baseline are shown in Table 3. Data for 1999 is included for comparison purposes. The FAPRI 2004 and 2009 price forecast for Iowa-southern Minnesota barrows and gilts are reported in Table 4. These price and quantity forecasts are based on the large forecasting model, FAPRI, which incorporates many relationships, including macroeconomic variables, policy variables as well as extensive agricultural market interaction.

To examine the impact of various environmental policies each region is assumed to have simple linear supply and demand schedules. The world market is assumed to clear at a single world price (the Iowa barrows and gilts price) when the total quantity supplied is equal to total quantity demanded. The elasticities of each supply and demand curve reported by Srivastava are shown in Table 5. The slope and intercept of each supply and demand curve is constructed so that they correspond to the price and quantity equilibria that prevail in the base scenario and have the elasticities as reported in Table 5.

A model structure this simple does not allow estimates of bilateral trade flows. However, the model does estimate the impact on world price and it estimates whether each region will either export or import, depending on world prices, and domestic supply and demand curves.

Table 3: Base line price and quantity estimates

		1999	2004	2009
			000 tonnes	
Canada	Production	1,525	1,877	1,882
	Consumption	1,010	1,099	1,171
China	Production	27,553	30,829	35,643
	Consumption	27,461	30,756	35,592
European Union	Production	17,900	18,183	18,451
	Consumption	16,750	17,048	17,193
Japan	Production	1,283	1,227	1,149
	Consumption	2,095	2,162	2,208
USA	Production	8,765	8,814	9,444
	Consumption	8,600	8,342	8,787
ROW Numbers	Production	14624	15567	16850
	Consumption	15325	16552	17891
World	Production	71,650	76,497	83,420
	Consumption	71,241	75,959	82,841

Source: Calculated from FAPRI, World Outlook 2000 (June)

Table 4: Iowa-Southern Minnesota Barrow and Gilt Price

year	Price (U.S. Dollars per Metric Ton)
1999	750
2004	895
2009	884

Source: Calculated from FAPRI, World Outlook 2000 (June)

Table 5: The Elasticities of Supply and Demand used in the Simulation Model

	Elasticity of Demand	**Elasticity of Supply**
Canada	-0.75	1.5
China	-0.3	0.5
EU	-0.75	0.9
Japan	-0.36	0.83
USA	-0.5	1
ROW	-0.5	0.9

Source: Srivastava

4.0 Simulated impacts of GHG policies on production and trade

4.1 Description of the likely scenarios

To illustrate the potential importance of GHG policy on trade and compare the magnitude of these effects to other domestic environmental policies, the impact of various polices are simulated within the trade model. In total five simulations made.

Scenario 1 imposes a Pigovian tax of $50/t on all hog producers in the world in 2004, and a $100 tax in 2009. Scenario 2 imposes the tax on Canada, US, EU, and Japan without imposing the tax on China and the ROW. Scenario 2 is plausible given the reluctance of China and many other lesser developed countries to be signatories to the Kyoto accord. In Scenario 3, Canada unilaterally imposes a GHG tax. Here it assumed that the other countries will either disregard emissions from the hog sector, or they fully subsidize the costs of GHG abatement. Given almost unilateral reduced level of subsidy that took place in the grain sector in Canada after the WTO, this situation is also plausible.

The forth and fifth scenarios simulated impacts of conventional regulation that could curtail the expansion of the US and EU. In scenario 4 the United States only expands production by half the rate predicted by FAPRI in 2004 and 2009. This scenario is based upon the idea that communities in the USA are currently uneasy and less willing to accept hog expansion in their backyard after the recent problems communities in North Carolina have gone through. In scenario five the production levels for the European Union in 2004 and 2009 are held steady at 1999 production levels. Consumption levels are assumed to be unchanged. Once again, this model was designed to depict the effects of tougher environmental regulations in countries such as the Netherlands and Denmark, which are very large hog producers. There are already laws in place requiring hog producers to scale back their production because of past over-expansion that led to nitrogen and phosphorus pollution. These simulations allow a comparison of magnitude trade effects of conventional environmental regulation of the hog industry versus GHG abatement.

4.2 Simulation results

The results of the five simulated scenarios are reported in Table 6. As shown in Simulation 1, when all countries apply a Pigovian tax for GHG emissions, there are relatively minor impacts. In 2004 with a $50 /t tax on pork, world production is reduced by 1.5% and only 3% in the case of the $100 /t tax. Given the elasticities used in the model, the consumer price increase is slightly larger than the price decrease to producers.

The simulation of Scenario 2 where taxes are only applied to the Canada, US, EU and Japan has very different results. Here the majority of the tax burden is born by producers in these countries, with a 4.3% and 8% reduction in prices in 2004 and 2009 versus a 1.3% and 3.3% increase in consumer prices. There is very little reduction (.6% and 1.5%) in GHG as China and the ROW increase production to offset much of the tax effect on emissions

The futility of a unilateral move to reduce emissions is most clearly shown in Scenario 3 where Canada only imposes the Pigovian tax. Here there is almost no impact on consumer prices (.13 and .3%) or world consumption levels, while the price impact on Canadian producers would be nearly the full amount of the tax (5.5% and 11%). The result is a significant (8.2 and 16.5%) reduction in Canadian production and virtually no impact on GHG emissions as producers in other countries offset the reduction in Canadian production.

The impacts on the Canadian hog industry resulting from these three GHG policies differ significantly. With a $50 /t tax applied to all world production, Canadian production declines by 2.5%, compared to a 6% reduction in production in 2004 when the tax is restricted to OEDC, and an 8% drop when it is restricted to Canadian production only. The differences between the simulations' resultant export levels and values are far more dramatic. In the first case the higher consumer prices restricts Canadian demand that nearly offsets the reduction in production. In this case there is a 3% reduction in exports. When the production tax is placed in Canada only, the same $50/t tax reduces exports by 23%. In this case there is a greater reduction in production, virtually none of which is offset by a reduction in consumption because consumer prices are unchanged. In the case of the $100 per tonne tax in 2009, Canadian exports decline by over 40%.

The effect of growth limiting environmental regulation in the US is illustrated in Scenario 4. The results of this simulation show almost no impacts on the world price of pork of .02% and .32% in 2004 and 2009 respectively. These results would suggest that future US regulation of the hog industry will have a very small impact on the international price, and therefore have a very limited impact the hog industry.

As shown in Scenario 5, an environmental cap on EU hog numbers has a very modest impact on the market relative to the FAPRI baseline. The results of this simulation show an increases in the world price of pork by .23% and .54% in 2004 and 2009 respectively.

Overall the environmental restrictions in the US and the EU will have a very limited positive impact on the world price and Canadian hog market. This supports the conclusion of Metcalfe (1998) that environmental regulations will have little impact in the market place.

Table 6: Simulation Results

Base Case	**2004**	**2009**	**% Change from Base**	
Year				
World Price ($/t)	895	884		
World Quantity Equilibrium (1,000t)	76,498	83,418		
Canadian Consumption (1,000t)	1,099	1,171		
Canada Production (1,000t)	1,877	1,882		
Exports Q (1,000t)	821	753		
Value of Exports (Million $)	734	666		
Scenario #1 - GHG tax* -all Countries	**2004**	**2009**	**% Change from Base**	
Producer Price ($/t)	881	846	-1.61%	-4.30%
Consumer price ($/t)	931	946	3.98%	7.01%
World Quantity Equilibrium (1,000t)	75,064	80,716	-1.87%	-3.24%
Canadian Consumption (1,000t)	-33	-62	-2.99%	-5.26%
Canada Production (1,000t)	-45	-122	-2.41%	-6.46%
Exports Q (1,000t)	808	693	-1.52%	-7.96%
Value of Exports (Million $)	711	586	-3.15%	-11.92%
Scenario #2 - GHG tax *imposed in Canada, US, Japan and EU	**2004**	**2009**	**% Change from Base**	
Producer Price ($/t)	857	813	-4.29%	-7.98%
Consumer price ($/t)	907	913	1.29%	3.33%
World Quantity Equilibrium (1,000t)	76032	82135	-0.61%	-1.54%
Canadian Consumption (1,000t)	-11	-29	-0.97%	-2.49%
Canada Production (1,000t)	-121	-225	-6.44%	-11.98%
Exports Q (1,000t)	710	557	-13.44%	-26.05%
Value of Exports (Million $)	608440	453206	-17.20%	-31.95%
Scenario #3 – GHG tax* - Canada only	**2004**	**2009**	**% Change from Base**	
Producer Price ($/t)	846	787	-5.46%	-11.00%
Consumer price ($/t)	896	887	0.13%	0.32%
World Quantity Equilibrium (1,000t)	76452	83296	-0.06%	-0.15%
Canadian Consumption (1,000t)	-1	-3	-0.09%	-0.23%
Canada Production (1,000t)	-154	-311	-8.19%	-16.50%
Exports Q (1,000t)	668	446	-18.62%	-40.85%
Value of Exports (Million $)	565041	350614	-23.10%	-47.36%
Scenario #4- USA one half projected growth	**2004**	**2009**	**% Change from Base**	
World Price ($/t)	895	887	0.02%	0.32%
World Quantity Equilibrium (1,000t)	76,490	83,295	-0.01%	-0.15%
Canadian Consumption (1,000t)	0	-3	-0.02%	-0.24%
Canada Production (1,000t)	1	9	0.03%	0.47%
Exports Q (1,000t)	821	765	0.09%	1.54%
Value of Exports (Million $)	735	678		
Scenario #5- European Union Production Unchanged from 1999	**2004**	**2009**	**% Change from Base**	
World Price ($/t)	897	889	0.23%	0.54%
World Quantity Equilibrium (1,000t)	76,416	83,208	-0.11%	-0.25%
Canadian Consumption (1,000t)	-2	-5	-0.17%	-0.40%
Canada Production (1,000t)	6	15	0.34%	0.81%
Exports Q (1,000t)	829	773	0.99%	2.65%
Value of Exports (Million $)	743	687		

Source: Simulated

5.0 Discussion

5.1 summary and Conclusions

As trade continues to liberalise in the world, comparative advantage will play a larger role in the location of industries. This is particularly true for the hog industry, which has a globally competitive market. The environment has become an important issue for the hog industry as many countries have introduced regulations to limit the impact on the aquatic and terrestrial ecosystems. More recently, with the framework convention on climate change, atmospheric accumulation of Greenhouse gases has become an important issue. This study examined the extent that environmental policies designed to limit GHG emissions could effect the location of hog production and international trade.

The analysis started with the premise that an international agreement to reduce GHG emissions will eventually be ratified. This being the case GHG from all sources will have a shadow value and will be potential target for reduction. While no precise estimates of this shadow value are available, the commonly used value of $20/t of CO_2 was used to illustrate the effects and determine the potential magnitude of impacts. Based on emissions per tonne of pork a simple Pigovian tax of $50/t of pork was imposed in 2004. This was doubled to a $100/t tax in 2009. Three different scenarios were run. In the first scenario, all hog production in the world was taxed, in the second, only Canadian, US, EU and Japanese production was taxed and in the final case only Canadian hog production was taxed. The result of the analysis revealed these Pigovian taxes were large enough to have significant impacts on production and trade. The impacts tended to somewhat larger that the potential impact of conventional environmental regulation of hog industry. They results also showed that if China and the ROW stayed out of a GHG agreement this could have large impact on the location and trade in the hog industry. The final scenario showed that a unilateral move to abate GHG in the hog industry in Canada could reduce exports by 23 to 47%.

5.2 Study limitations

The are many limitations to this very preliminary study. The $50 Pigovian tax on hog production is based on the $20/t cost economy wide CO_2 abatement costs. The estimates of these costs in the literature range from over $200 per ton to $2/t. More precise estimates of abatement costs are needed. The analysis uses Canadian estimates of GHG emissions per hog and fixed proportions between GHG emissions and hog production. More analysis is needed to relax each of these assumptions as information becomes available. Beghin et al. (1997) showed the linkages between trade policies and environmental policies and suggested that they could be used together to increase efficiency and mitigate pollution. These types of instruments need to be explored in the case of GHG abatement.

5.3 Further research

The GHG externality of $50 per tonne for pork production suggests that these costs are large enough to have an impact on production. The realized trade and production impacts will very much depend on which countries participate in an agreement and how GHG abatement policies are introduced in each country. The estimates presented here show that without universal application these policies could substantially alter competitive advantage within the industry and the pattern of trade flows. The implementation of climate change agreements clearly have the potential to significantly affect trade patterns. These effects would be another source for trade disputes, and eventually lead to new trade rules. Trade economists need to become involved in the development of international climate change negotiations, to mitigate at least some of the potential trade conflicts that could arise.

The are several other areas that warrant further research. Given the size of Chinese hog production, more research into the environmental constraints and policies in China is required. Given the potential magnitude of the GHG impacts there is a need to understand the technologies that may reduce GHG emissions from hog production. In order to understand the potential impact of GHG on hog production, there is a need to examine the potential affect of GHG abatement on poultry and beef production. If costs in these sectors are increased because of GHG policy the pork sector could be a net beneficiary. There is need to understand these relationships better.

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