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The Effect of British Columbia's *Carbon Tax on Agricultural Trade*

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EXECUTIVE SUMMARY

The implications of an existing carbon tax on international trade in the agricultural sector in British Columbia (BC) are evaluated in this white paper. The province unilaterally introduced a carbon tax on July 1, 2008 and applied it uniformly to all fossil fuels purchased and combusted within the BC borders, with the sole exemptions being inter-jurisdictional ship and aircraft fuel. In 2012, the province granted an additional exemption from the tax, this time to certain agricultural sectors. Using trade statistics specific to individual agricultural commodities and comparing provinces over a multi-year interval, we find little evidence that the carbon tax was associated with any statistically significant effects on agricultural trade or competitiveness from 2008-2011, despite the sector being singled out as "at risk" by the provincial government. These findings suggest that there is not compelling evidence for exemption of the agricultural sector from the tax. Policy options to address potential effects of the tax on the sector's profitability and international competitiveness––should they arise in future––are also discussed. Based on this analysis, it is suggested that at present, the case for granting specific carbon tax exemptions to the agricultural sector is weak.

There is one caveat, however: the research reported here was based on aggregate agricultural commodities data. These limit the precision of the analysis at the company or farm-gate level. The relatively short time (2008-2011) of the assessment period also limits the precision of the analysis. Finer-scale work and longer time-series information should yield more robust assessments in future years of the impact of the carbon tax on performance at the individual farm or commodity level.

1. INTRODUCTION

On July 1, 2008, British Columbia introduced a carbon tax on all fossil fuels purchased in the province, the sole exceptions being aviation and marine fuels used in inter-jurisdictional transportation. Carbon taxes are considered to be among the most efficient market-based instruments available to reduce greenhouse gas (GHG) emissions. They raise revenue that can be used for productive purposes such as reducing other taxes,[1] provide strong incentives for technological innovation,[2] and have small transaction costs.[3] Further, BC's carbon tax combines a unique set of policy characteristics, placing it among the best designed environmental policies in the world: i) the carbon tax is coupled with targeted rebates to low-income and remote households, alleviating concerns over differential negative impact on sectors of society; ii) revenue from the carbon tax is used to reduce rates of corporate and personal income taxation, a design that admits the possibility of a "double dividend" (i.e., a reduction in GHG emissions as well as an increase in economic output);[4] and, iii) the tax applies an identical rate to all emitters. This approach ensures greenhouse gases are reduced at the lowest social cost.

Yet, while the tax is well designed, it was enacted unilaterally and applies exclusively to fuel purchasers within BC. As a result concerns linger over its consequences on particular sectors. For example, differential environmental regulations may cause firms operating in BC to move to other un-taxed jurisdictions. This can reduce the effectiveness of the tax (and compromise efficiency) and undermine domestic support for the policy. Difficulties are greatest in sectors with relatively high greenhouse gas intensity, as well as those that face international trade pressure and those that receive little benefit from the revenue-recycling mechanisms that accompany the tax. As such, in its 2012 budget speech, the BC Government looked to "examine the tax's impact — both positive and negative — on every economic sector". Of note, the government stated its intention to "pay particular attention to agriculture, recognizing its critical importance to our future".[5]

Singling out the agricultural sector as “at-risk” is likely the result of the pre-budget consultation process. Industry representatives claimed that the tax was “devastating” agricultural producers and that “it is one of the hardest-hit industries when it comes to the carbon tax”.[6] They also claimed that, “There is no offset for [agricultural producers], so no matter what you give back in taxes, it doesn’t matter”.[7] As a result of these deliberations, certain agricultural subsectors were granted exemptions from the BC carbon tax starting in 2012. The BC Government did not provide empirical evidence to justify the agricultural sector’s exemptions, nor did it specify which criteria or evidence would support other sectors’ exemptions from the tax based on competitiveness arguments.

This paper uses national data from Statistics Canada and Industry Canada to evaluate empirically the consequences of the BC carbon tax on international trade in agricultural commodities. We exploit a commodity-specific data set that reflects trade in all provinces between 1990 and 2011, prior to agricultural exemptions being implemented. After controlling for geography and factors stable in time such as world commodity prices, national tariffs, and environmental policies in other countries, as well as other influences (e.g., weather), we find little evidence that the implementation of the BC carbon tax from 2008 on is associated with a decline in exports or increase in imports from the agricultural sector.

This finding is based on limited data that span just three to four years after the tax was imposed, an interval too short to yield precise statistical confidence. Despite this constraint, the absence of any significant trends is telling: there is no evidence to support the notion that international trade in the BC agricultural sector has been affected by the tax. While public pressure may induce governments to compensate sectors following the introduction of similar taxes, such provisions should be based on evidence that the tax is having a detrimental impact on the sectors in question. In the current case, the analysis shows that there was no evidence of detrimental trade impacts on the agricultural sector.

2. OVERVIEW OF THE BRITISH COLUMBIA CARBON TAX

The introduction of the BC carbon tax surprised the majority of British Columbian residents.[8] Announced by the province’s Finance Minister in her February 2008 budget speech, the tax was implemented very quickly. By July 1st, 2008, BC became the first jurisdiction in North America to introduce a revenue-neutral carbon tax.[9] Early reactions to the tax were positive and polls showed that a majority of voters supported the policy.[10] Residents appear to have understood the impetus for the tax and accepted that it was a well-designed policy. The most notable demonstration of popular support was when the Liberal Party of British Columbia, the political party that introduced the tax, was granted a third consecutive majority government in a “post-carbon-tax” election.

The carbon tax is comprehensively applied to all greenhouse gas emissions generated in the province from burning fossil fuels, with the effective tax rate for each fuel-type based on its carbon content. The tax rate started at \$10 per tonne of carbon dioxide equivalent emitted (CO_2e) in July 2008 and increased by \$5 per tonne every year reaching \$30/tCO_2e by July 2012.[11] At \$10/tCO_2e, the tax represents an increase of 2.69¢/litre of diesel; at \$30/tCO_2e this increases to 7.67¢/litre. Increasing the level of the tax through time allowed consumers to adjust their fuel usage gradually and change their habits. This feature of the policy also facilitated investment planning by firms and individuals, since a fixed five-year schedule of tax rates was legislatively mandated.

The BC carbon tax is revenue neutral, and generated an estimated $960 million in 2011-2012.[12] Revenue neutrality requires returning all carbon tax revenues to residents via adjustments to personal and corporate taxes as well as via lump-sum transfers. The tax revenue to the BC Treasury was therefore returned to taxpayers in the form of lower personal, corporate and small business income taxes. Other tax-shifting provisions in the legislation included reduced school property taxes for land classified as "farm", property tax credits to industries, and monetary transfers to lower-income families and northern and rural homeowners.

Despite these tax shifts, there is a perception that the carbon tax is reducing the competitiveness and profitability of the BC agricultural sector while dramatically increasing energy costs associated with commodity production. The carbon tax was introduced during an uncertain period for producers. A high Canadian dollar, volatile commodity prices and lack of trade protection has been called a "perfect storm" for the farming community. The coincident timing of these challenges with the introduction of the carbon tax may have led BC farmers to target and blame the carbon tax for the difficulties they face.[13]

A major reason for the dislike of the carbon tax in the agricultural sector is the perceived difficulty in decreasing fuel use in the short-run in order to adapt to the tax. Heating greenhouses and harvesting crops with machinery, for example, are essential to the proper functioning of many farms. An increase in the price of fuels drives up energy costs and could lead to adverse results: for example, potentially decreased profits, reduction of planted acres, a decline in net exports or even farms leaving the BC industry altogether.

As a result of these perceived challenges, in 2012 the government granted BC's high-tech greenhouse vegetable and horticulture growers a one-time, $7.6 million reprieve from the carbon tax, "allowing producers to focus on maintaining their competitive edge".[14] This was followed in the 2013 Budget by a permanent grant program for commercial greenhouse growers (vegetable, floriculture, wholesale production and forest seedling nurseries) that is set at 80 percent of the carbon tax paid on natural gas and propane for heating and carbon dioxide production. Effective January 1, 2014 farmers were exempted from the carbon tax on the purchase of coloured gasoline and coloured diesel fuel for farm use. And in Budget 2014, Carbon Tax Relief for the Greenhouse Sector provides an incremental $1 million over three years for the Greenhouse Carbon Tax Relief Grant program.

The objective of these exemptions is to enable BC growers to compete better with producers in the USA and Mexico. However, as exemptions can impose large efficiency costs,[15] they should only be considered when there is compelling evidence that a sector is being displaced by output from other regions. To our knowledge, this evidence was never produced when justifying the exemption to BC's agriculture sector. This paper is aimed at evaluating the case for exemptions for the agriculture sector.

3. EMPIRICAL ANALYSIS

The empirical analysis that follows is divided into several subsections. First, we examine whether BC's agricultural sector should be considered carbon-intensive compared to other trading sectors operating within the province. Next, we present our methodology and data and the results of a series of models that explore the effect of the carbon tax on agricultural exports and imports. Finally, we discuss our results in light of the tax exemptions that have been granted to the agricultural sector.

3.1 Is BC's agricultural sector carbon-intensive?

The introduction of unilateral environmental regulations in a small open economy increases domestic costs of producing pollution-intensive goods and may induce comparatively disadvantaged pollution intensive production to shift from a regulated jurisdiction to an unregulated jurisdiction.[16] However, even though unilateral environmental regulation reduces output and net exports in the dirty sector – as factors shift out of the dirty sector into the clean sector – output and net exports in the clean sector potentially increase. As such, it is useful to categorize sectors as "clean" or "dirty" according to carbon intensity in order to predict whether a given sector is likely to expand or contract in response to a carbon tax.

While classifying clean and dirty commodities is straightforward in theory, it is less so in practice. Multiple sectors produce a range of outputs; some goods are produced exclusively for domestic markets, while others are exported. As an approximation however, it is possible to pinpoint sectors, based on the structure of BC's economy, that have the largest probability of being adversely affected following the introduction of a unilateral carbon tax.

Commodities that are not highly traded are unlikely to experience large changes in imports or exports as a result of unilateral environmental policy. Similarly, sectors that do not consume substantial fossil fuels are unlikely to experience large cost increases due to the carbon tax, and thus be disadvantaged in their ability to compete with foreign producers. Therefore, commodities that use a high proportion of fossil fuels in production and those that are highly traded (thus, trade-exposed) are most susceptible to pressures from international competition.

Concerns over energy-intensive and trade-exposed sectors have been widely used in the design of policies elsewhere. For example, the Waxman-Markey cap-and-trade bill, a prominent piece of American legislation that failed to pass the US Senate in 2009, defined a sector as energy-intensive and trade-exposed if energy expenditures represented more than 5 percent of total costs, and if trade intensity was greater than 15 percent.[17] Figure 1, demonstrates that most commodities produced in BC have both low trade intensity and low fossil fuel intensity.[18] This reflects the fact that services, which dominate BC's economy, are typically not highly traded and have low energy-intensity. There is a natural break in the data at a trade intensity of 0.5, so we consider goods with trade intensity greater than 0.5 as "highly traded".

Figure 1 makes it clear that agricultural goods are highly traded. Compared to other highly traded goods produced in BC however, agriculture does not stand out as particularly fossil fuel intensive. Production of fruit, vegetables, other food products and feeds and production of meat, fish, and dairy products have cost shares of approximately 0.04 for fossil fuels (i.e., 4 per cent of total costs are for fossil fuels). This is larger than the cost share of fossil fuels for services, but equal to or lower than the cost share of fossil fuels in many manufactured goods.

Whether agriculture should be considered dirty or clean is not obvious. Likewise, the trade intensity of about 0.6 is greater than that of domestically oriented commodities (services), but less than that of internationally traded manufacturing commodities. While theory clearly suggests that exports from the dirty (clean) sector should decrease (increase) following imposition of a carbon tax, the classification for agriculture is ambiguous and no clear theoretical predictions are available. Thus, we move to an empirical approach to understand better the impact of the tax on trade.

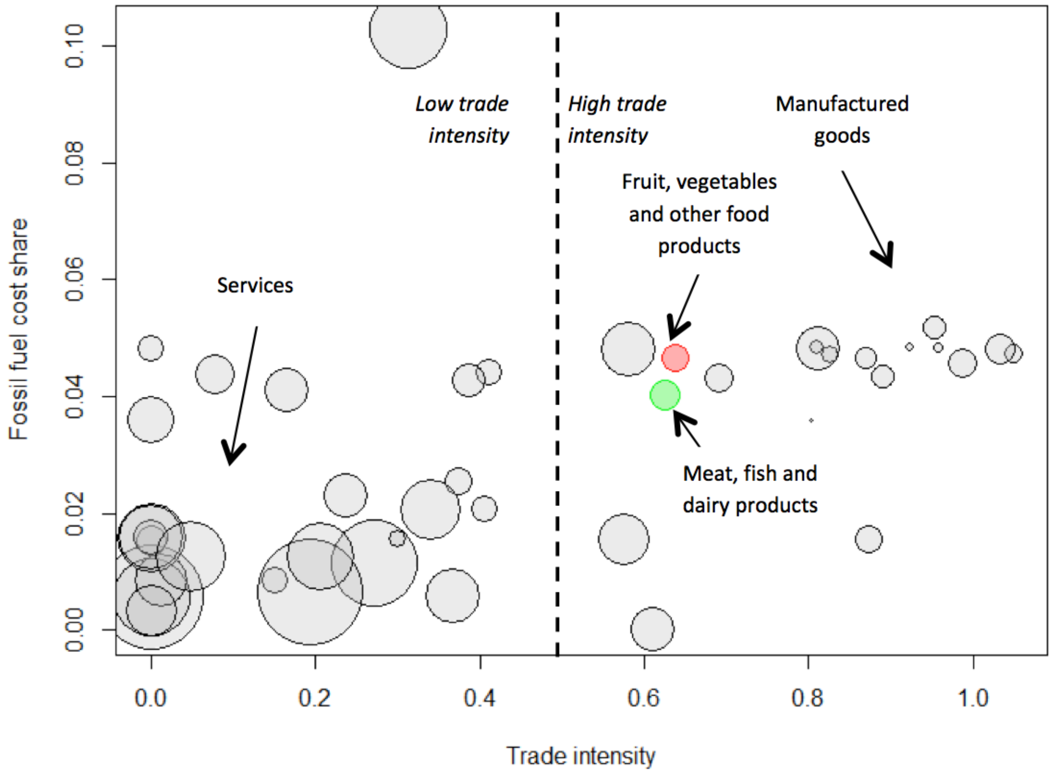

Figure 1 *Trade intensity and fossil fuel cost share for BC commodities, 2007. The data on fossil fuel usage by sector and trade by commodity were extracted from Statistics Canada's System of National Accounts. The area of the circles is proportional to total domestic output of commodities in BC in 2007. The vertical axis represents the cost share of fossil fuel inputs required to produce a unit of each commodity, while the horizontal axis represents the trade intensity of each commodity, i.e., the fraction of a given commodity that is traded across BC's borders.*

3.2 Estimating the effect of the carbon tax on agricultural trade

Recent economic analyses have shown that environmental regulations have a modest effect on trade, investment and plant location decisions.[19] Levinson and Taylor (2008), for example, estimated that a doubling in pollution abatement expenditures in response to more stringent US environmental regulation between 1977 and 1986 led to an increase in net imports of pollution-intensive goods from Mexico of around 40 percent.

There are two reasons why a prospective negative relationship between exports and environmental regulation is important for policymakers. First, out-migration of polluting industries, from regulated to unregulated jurisdictions, works against the objectives of the policy because unwanted emissions are partly transferred to the unregulated jurisdiction. Second, if unilateral environmental policy causes a shift of economic activity to other countries, there will be a decline in domestic welfare associated with losses in industry competitiveness. This concern occupies a central position in many policy discussions, including those in British Columbia.

Competitiveness is an imprecisely defined term, loosely used to refer to profits, employment and trade among other things. In an effort to examine the impact of the BC carbon tax on "agricultural competitiveness", we constructed a dataset covering international trade and output in agricultural commodities in all Canadian provinces. In particular, we obtain agricultural trade data from Industry Canada, output data from Statistics Canada, and weather data from Environment Canada. We then use these data to estimate whether there is a relationship between the introduction of the BC carbon tax and international agricultural trade patterns.[20]

3.3 Results

The evolution of net exports of aggregate agricultural products for each Canadian province over the period 1990-2011 is shown in Figure 2. Significant volatility is apparent even given the high level of aggregation that the data represent. Net exports from Alberta and Saskatchewan fell dramatically in 2003, corresponding to the discovery of bovine spongiform encephalopathy (BSE) in an Albertan steer. Exports from these provinces then increased rapidly in the period around 2008. There are also large fluctuations in agricultural trade concurrent with the 2009 recession. Like Ontario, BC is a net importer of agricultural commodities (thus net exports are negative in the figure). In both provinces net imports gradually increased from 2004 on. We note that there is little change in that trend in BC after 2008 when the carbon tax was introduced. Overall, the data do not reveal any changes in the pattern of agricultural trade that can be conclusively linked to the carbon tax.

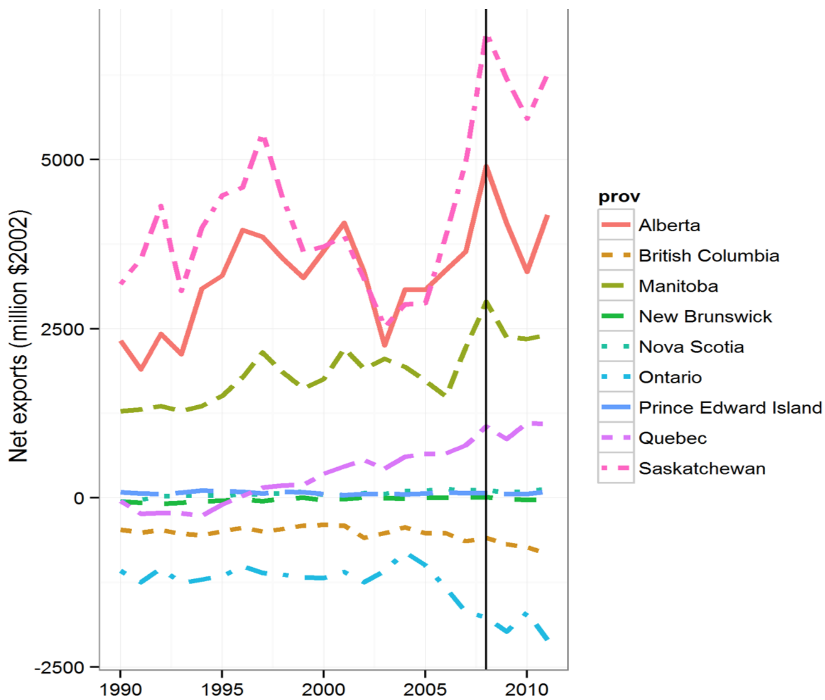

Figure 2: *Net exports from agriculture by province, 1990-2011, in constant 2002 dollars. Data sources as described in the text. The black vertical line indicates the time of introduction of the BC carbon tax.*

The numerical context for Figure 2 is provided in Table 1. Here, we summarize growth rates of agricultural exports, both prior to and following the introduction of the carbon tax (note that Table 1 is for gross exports, while Figure 2 is for net exports). Panel A in Table 1 compares 2001-2007 (prior to the 2008 introduction of the tax) with 2009-2011 (post tax). The first row shows that exports of agricultural commodities from BC declined by 3.93 percent per year in real terms during the early part of the decade, and by 4.07 percent per year from 2009 to 2011. The second row repeats the calculations for the rest of Canada: exports grew by 0.82 percent annually in other provinces in 2001-2007 and by 1.76 percent in 2009 to 2011. The right-hand column shows the difference in the export growth rates in the two intervals in BC and the rest of Canada. The bottom-right value in Panel A presents the difference-of-differences and indicates that there was a decline of 1.08 percent in gross exports per year after the carbon tax was introduced. This implies that the tax had a negative effect on exports.

Table 1: Annual average growth rate in per cent of the real dollar value of gross agricultural exports in BC compared to the basket of other provinces shown in Figure 2.

Panel A			
	2001-2007	2009-2011	Difference
British Columbia	-3.93	-4.07	-0.14
Other provinces	0.82	1.76	0.94
Difference	-4.75	-5.83	-1.08
Panel B			
	2000-2008	2008-2011	Difference
British Columbia	-0.49	-4.86	-4.37
Other provinces	5.39	-2.93	-8.32
Difference	-5.88	-1.93	3.95

But caution is required before such a conclusion can be drawn. The tax was introduced on July 1, 2008 and slightly shifting the window of analysis generates completely different results. Calculations in Panel B use adjusted windows: 2000-2008 and 2008-2011. This one-year change, with overlap in 2008, yields results that suggest a positive impact of the tax – the difference-of-differences calculation indicates that BC's gross agricultural exports increased by 3.95 percent per year relative to the rest of Canada.

Clearly, high-level comparisons of the type reported here are insufficient to determine with any confidence the impact of the carbon tax on trade. Moreover, Table 1 highlights two challenges that arise when using simple averages to evaluate environmental policy. First, trade is highly volatile over time, an observation reinforced by the data in Figure 2, and comparative results are therefore sensitive to selection of the period of analysis. Second, there is likely substantial heterogeneity across specific commodities on a year-to-year basis even within provinces – for example, Alberta's aggregate agricultural sector was highly affected by BSE in 2003 because cattle comprise a larger share of exports than in other provinces. However, it is possible to control for the border closure that affected beef and cattle exports as well as other commodity-specific heterogeneity. This can be accomplished using more formal econometric analyses as described below that promise to yield better identification of carbon tax impacts.

Following similar papers, we evaluate the influence of the carbon tax on gross exports and gross imports using a regression approach.[21] This requires that the dependent variable, i.e. exports or imports, be expressed relative to domestic output, a normalization step that accommodates the wide distribution in sector size found in trade data. The results are reported in Table 2 and correspond to the analysis in Table 1. The regression analyses in both columns include effects of annual variability in commodity production ("commodity-year fixed effects"), effects specific to particular commodities in individual provinces ("good-region fixed effects"), and effects attributable to annual weather impacts. The commodity-year variables accommodate much of the volatility in commodity prices as well as other commodity-specific events that occur on a year-to-year basis. The values in this table represent the degree to which an impact of the carbon tax can be related mathematically to changes in either normalized exports or imports. The numbers in the top line are estimates of the coefficient a, the carbon tax variable. (Details of the data set and method are in Rivers, N. and Schaufele, B., "The effect of carbon taxes on agricultural trade" Canadian Journal of Agricultural Economics, forthcoming).

A positive value suggests that an increase in the carbon tax is associated with an increase in the variable in question. In the case of gross exports, the coefficient is positive and statistically significant at the 1 percent level, suggesting an increase in gross agricultural exports coincident with the carbon tax, even after controlling for other factors. The coefficient on gross imports is not significantly different from zero. If the analysis ended with Table 2, we would conclude that BC's carbon tax led to an increase in agricultural exports. But this conclusion is shown to be misleading when commodity-specific heterogeneity is introduced, as discussed below.

Table 2: Regression results with logged exports and imports normalized by domestic output as dependent variables and the carbon tax, good-region fixed effects and commodity-year fixed effects, and weather as the independent variables. The numbers in the top line ("Carbon tax") are estimates of change in normalized imports and exports associated with an increase in the carbon tax. Positive values suggest a positive relationship between these two variables, after controlling for other variables. Y indicates inclusion in the analysis of commodity-region and commodity-year fixed effects and weather effects. N indicates that these effects were ignored.

	Gross exports	Gross imports
Carbon tax	0.061**	0.002
	(0.024)	(0.026)
Commodity-region fixed effects	Y	Y
Commodity-year fixed effects	Y	Y
Weather effects	Y	Y
R^2	0.88	0.85
Obs.	2332	2332

*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$; Robust standard errors in parentheses.

Table 3 repeats the analysis of Table 2 but uses non-normalized data for commodity exports and imports. In Table 3, rather than regress the raw export or import numbers for a given year against the carbon tax amount appropriate for that year, we have regressed the difference between one year and the next in the dependent variables (exports and imports) against the difference in the carbon tax from one year to the next (the independent variable). This approach can be useful in accommodating correlation over time in variables. Table 3 lists results for four different statistical combinations. Columns (1) and (3) do not include controls (for example, for weather-related impacts and fixed effects); first differences in log (exports) and log (imports) are regressed against first differences in the carbon tax. This approach yields results in column (1) that are not statistically significant from zero, unlike the case for gross exports in Table 2. Column (3) shows a decrease in imports, but again with no statistical significance. Columns (2) and (4) repeat the same regressions, this time controlling for time-varying fixed effects. The coefficients for both gross exports and gross imports move nearer to, and are statistically indistinguishable from, zero. These results suggest that there is no statistical basis to conclude that the carbon tax in British Columbia influenced agricultural exports or imports in either a negative or positive sense in the 2008 to 2011 interval for which data are available.

Table 3: First-differenced estimates of log(gross exports) and log(gross imports) regressed against year-to-year differences in the carbon tax and other controls. The numbers in the top line ("Carbon tax") are values of the carbon tax coefficient. Y indicates inclusion in the analysis of commodity-year fixed effects and weather effects. N indicates that these effects were ignored.

	Gross exports		**Gross imports**	
	(1)	(2)	(3)	(4)
Carbon tax	0.014	0.008	-0.023	-0.007
	(0.022)	(0.023)	(0.034)	(0.035)
Commodity-year fixed effects	N	Y	N	Y
Weather effects	N	Y	N	Y
R^2	0.00	0.27	0.00	0.26
Obs.	1871	1871	1662	1662

$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$; Robust standard errors in parentheses.

The analysis to this point assumes that the impact of the carbon tax on all agricultural commodities would be identical. This assumption is clearly unrealistic; diverse technologies and the degree of competition affect different commodities differently, and some agricultural subsectors are likely to be more exposed to the carbon tax than others. The next set of regressions explores this issue. Table 4 (in Appendix 3) reports results for regression models that use first-differences of gross exports as the dependent variable, while Table 5 (also in Appendix 3) reports results for the same model specifications but with first-differenced imports as the dependent variable. In total six models are estimated for each dependent variable (12 models in total), and export and imports of specific commodities are each regressed against the first-differenced carbon tax. This approach captures commodity-specific heterogeneity. Figures 3 and 4 illustrate the key outputs from these commodity-specific regressions.

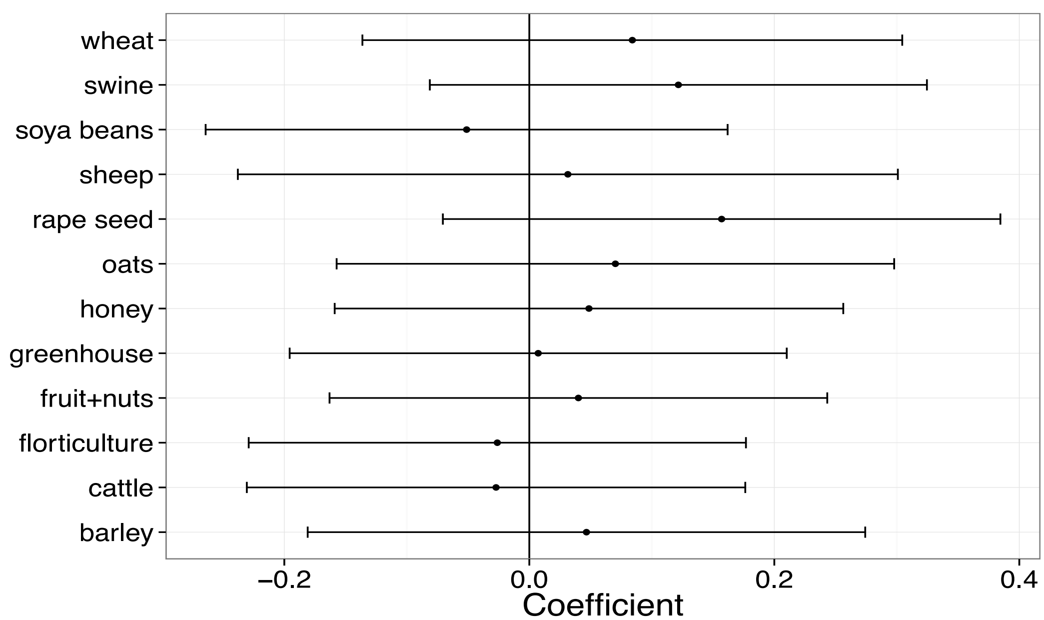

Figure 3: Effect of the carbon tax on gross exports from British Columbia of 12 different commodities, determined using the regression approach described in the text applied to export data from 2008 to 2011The values for the carbon tax coefficient (x-axis) are taken from Column 2 of Table 4 in Appendix 3. The horizontal bars represent 95 percent confidence intervals.

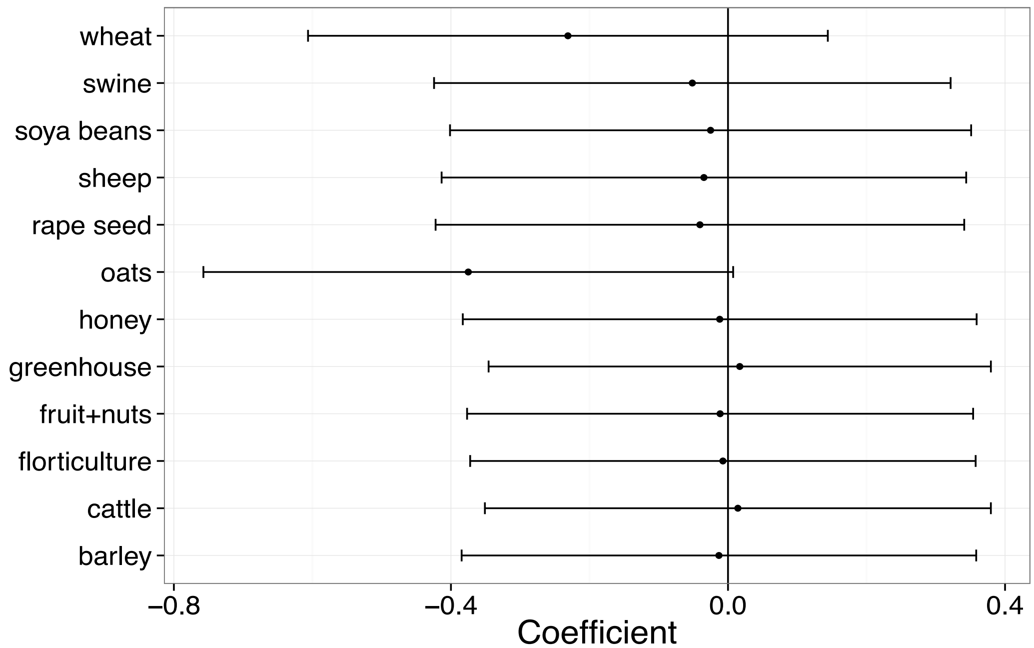

Figure 4: *Effect of the carbon tax on gross imports to British Columbia of 12 different commodities, determined using the regression approach described in the text applied to import data from 2008 to 2011. The values for the carbon tax coefficient (x-axis) are taken from Column 2 of Table 5 in Appendix 3. The horizontal bars represent 95 percent confidence intervals.*

As can be seen in both Figures 3 and 4, there is no trend in either exports or imports attributable to the carbon tax that is significantly different from zero at the 95% confidence level. However, the majority (9 of 12) of the commodities examined in Figure 3 imply that agricultural exports of those commodities increased contemporaneously with the carbon tax. While this could be interpreted as an improvement in competitiveness, it must be emphasized that confidence intervals around the discrete estimates are large and are sensitive to the specifications used in the model. The prudent conclusion is that no significant trends are detectable, at least as yet, given the relatively short time duration since the tax was introduced.

3.4 Discussion

Our analysis confirms that no consistent and credible link can yet be made between the BC's carbon tax and agricultural trade patterns. It remains possible that as data accumulate over a longer period of time this conclusion could change, but at this point that is only speculation. This conclusion runs contrary to the conventional wisdom in the sector. In fact, the exemptions granted to the greenhouse sector and the broader agricultural sector were based on the claim that international agricultural competitiveness was compromised by the carbon tax.

What, then, can explain our rather unusual findings? First, it is possible that the carbon tax had a small effect on the agricultural sector; other influences such as land quality, climate and human capital may have swamped any impact of the tax over the last several years. This hypothesis can be tested by a simple accounting exercise. Suppose that the average fuel cost share for agriculture is 4 percent, as indicated by the results in Figure 1. If the carbon tax comprises a 10 percent increase in the cost of fuel (for reference, the price of a litre of diesel fuel increased by 7.67c as a result of the carbon tax), then the carbon tax generates a maximum increase in overall costs to the producer of ~0.4 percent. This indeed implies that the carbon tax may have had only a small effect on the agricultural sector.

Second, as discussed earlier, carbon taxes are likely to reduce net exports from carbon-intensive (dirty) sectors, but potentially increase net exports from other (clean) sectors. If agricultural production in BC is not carbon-intensive relative to other traded sectors––which appears to be the case––then the marginal increase in exports following the introduction of the tax (as per Table 1) is consistent with theory. This is supported by the data in Figure 1 that suggest that on average the agricultural sector is less carbon-intensive than many other highly-traded sectors. Lower carbon intensity confers a comparative advantage.

Finally, the introduction of the carbon tax may have stimulated process innovations or intra-industry substitutions on BC farms. If so, such adaptations could have offset any first-order effects of the carbon tax.

4. POLICIES TO ADDRESS COMPETITIVE CONCERNS OF CARBON TAXES ON AGRICULTURE

The analysis presented in this paper offers no concrete evidence that net international exports from BC agricultural firms declined following implementation of the carbon tax. We note, however, that this study does not analyse the impact of the tax on farm profits or performance. For reasons of economic efficiency or distributional impacts across the province, therefore, the BC government may wish to mitigate any negative impacts on agriculture associated with the tax, should they be shown to exist. Three policy options are immediately available: (1) sector exemptions, (2) lump-sum rebates, and (3) output-based rebates.[22] We discuss each in turn.

4.1 Exemptions

When implemented elsewhere (notably in Europe), carbon taxes have often been accompanied with exemptions for certain sectors to shield them from the full impact of the tax. Such exemptions have taken various forms, including complete exemptions such as Norway's exemption on coal use in the cement industry,[23] conditional exemptions such as the UK's Climate Change Agreements and Levy,[24] and reduced tax rates which exist for most manufacturers subject to European carbon taxes.[25] While such exemptions are politically popular, most economists consider them to be economically inefficient because they do not encourage exploitation of opportunities to reduce carbon emissions. Moreover, sector exemptions are an extremely costly way to preserve employment in the exempted sector,[26] and are inferior to other support mechanisms that governments can use.[27]

Conventional economic wisdom suggests that the number of policy instruments should be equal to the number of policy goals. In the context of BC's carbon tax, there are three primary goals: (1) improving environmental performance; (2) maintaining international competitiveness; and (3) maintaining employment or firm profitability following introduction of the tax. Trying to address all three of these with a single policy (carbon tax with exemptions) is sub-optimal and compromises efficiency across all goals. Instead, we suggest that individual policies should be used to address each policy goal.

4.2 Lump-sum rebates

Rebates are an alternative form of compensation for affected sectors and can be unconditional (lump-sum) or conditional. In the current context, they would be used to support firms' profits during a transitory period when carbon taxation was applied. A recent analysis estimated that for energy-intensive firms in the US, preserving profits following implementation of a carbon tax would require a lump-sum transfer equivalent to about 15 percent of total carbon tax payments.[28] A 100 percent lump-sum rebate substantially over-compensates industries. Several market-based climate policies do provide substantial lump-sum rebates for participating sectors. For example, the European Union's Emission Trading System uses a lump-sum allocation of emission permits to industrial facilities, similar to the allocation system in the US sulphur dioxide trading program. Importantly, a lump-sum rebate is not tied directly to a firm's current carbon emissions or fossil fuel use (or any other current-year variable) – this is what distinguishes it from an exemption. Instead, lump-sum rebates could be distributed on a per-firm basis or based on historic emissions. In this way, the rebate functions purely as a transfer mechanism and does not influence decisions at the company level.

4.3 Output-based rebates

Conditional rebates offer an alternative to lump-sum rebates, and depend on a firm's performance. In this approach, payments are calculated on the basis of physical or economic output.[29] For example, a sector may receive a rebate that is some percentage of total carbon tax payments. Allocation of the rebate to firms within the sector would be based on proportionate physical output (e.g., tonnes of corn produced), rather than carbon tax paid. This approach provides the firm with two incentives: first, because of the carbon tax, each firm has an incentive to reduce emissions; and, second, because the allocations to firms is contingent on their share of sector output, each firm has an incentive to increase output. This type of structure helps to mitigate some of the negative impacts of the tax on "competitiveness", and simulations suggest it can be effective.[30]

5. CONCLUSIONS

This paper focused on an evaluation of the impact of the BC carbon tax on international trade in agricultural commodities that cross the borders of the province. Two primary conclusions can be drawn from this assessment: a) amongst highly traded sectors in BC, the agricultural domain has a fossil fuel intensity that is approximately average. A simple theoretical model does not unambiguously predict an impact of the carbon tax on net agricultural exports from the province that can be tied to the intensity issue; b) comparisons of imports and exports of a number of agricultural commodities in each province in Canada over the 21 year period from 1990 to 2011 reveal no conclusive connection between the carbon tax and agricultural trade. These comparisons were controlled for time-varying factors that are similar for all provinces (world commodity prices, national tariffs, costs and environmental policies in other countries), weather, and time-invariant factors that are specific to each province (e,g, comparative advantage). Based on the analysis and these conclusions, it appears that exemptions from the carbon tax for the greenhouse sector––established in 2012 as a one-year exemption and made permanent in 2013, rooted primarily in concerns over international competitiveness––cannot be justified by currently available commodity export data.

This final conclusion is tempered by one caveat: the research was based on aggregate data that limit the precision of the analysis at the company or farm-gate level. Future econometric work based on firm-level microdata, along with longer time-series information on specific commodity imports and exports, should yield more robust assessments of the impact of the carbon tax on firm performance at a finer scale. This is a fruitful avenue for future research.

6. ENDNOTES

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8 Harrison, K. (2012). A Tale of Two Taxes: The Fate of Environmental Tax Reform in Canada. Review of Policy Research , No. 3.

9 The city of Bolder Colorado and the rovince of Quebec implemented carbon taxes in 2007, but at much lower levels than in British Columbia.

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17 Trade intensity, as defined in the Waxman-Markey bill and adopted here, is (imports+exports)/(imports+domestic output). Trade intensity for the US as a whole is much lower than for a Canadian province due to differences in size.

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8. APPENDIX

This Appendix includes two tables: Table A3.1 reports regression results for a series of models that use gross exports as the dependent variable, while Table A3.2 reports results for the same model specifications using gross imports as the dependent variable. In total six models are estimated for each dependent variable (12 models in total). Each regression interacts the carbon tax with commodity indicators, capturing commodity-specific heterogeneity.

Table A3.1: First-differenced results with commodity-specific heterogeneity and the natural log of the real value of gross exports as dependent variable. Column (1) includes commodity-year fixed effects. Column (2) maintains commodity-year dummy variables and adds a linear time trend for each commodity-province pair. In column (3) a quadratic time trend is added for each commodity-province pair to the previous specification in column (2), while column (4) incorporates a cubic time trend for each commodity-province pair. Increasing the flexibility of trends helps to address the volatility in the import and export series over time. It also ensures that unobserved events are not attributed to the carbon tax. Finally, columns (5) and (6) are identical to column (2), but restrict the sample to post-2000 and post-2005 respectively. Shortening the sample ensures that the results are robust to any potential structural shifts in BC's agricultural sector that occurred within the last decade. All models include commodity-year fixed effects as well as weather controls.

	(1)	(2)	(3)	(4)	(5)	(6)
Carbon tax*cattle	0.003	-0.027	-0.051	-0.050	-0.058	-0.079
	(0.076)	(0.104)	(0.122)	(0.124)	(0.123)	(0.128)
Carbon tax*swine	0.078	0.122	0.147	0.143	0.118	0.133
	(0.076)	(0.104)	(0.122)	(0.124)	(0.123)	(0.127)
Carbon tax*sheep	-0.053	0.031	0.091	0.208	0.092	0.143
	(0.080)	(0.137)	(0.155)	(0.163)	(0.166)	(0.399)
Carbon tax*honey	0.053	0.049	0.082	0.082	0.033	0.054
	(0.077)	(0.106)	(0.124)	(0.127)	(0.125)	(0.130)
Carbon tax*floriculture	-0.016	-0.026	-0.016	-0.018	-0.022	-0.021
	(0.076)	(0.104)	(0.122)	(0.124)	(0.123)	(0.127)
Carbon tax*vegetables	-0.007	0.007	0.016	0.015	0.023	0.015
	(0.075)	(0.104)	(0.122)	(0.124)	(0.123)	(0.127)
Carbon tax*fruit & nuts	0.007	0.040	0.042	0.051	0.039	0.049
	(0.076)	(0.104)	(0.122)	(0.124)	(0.123)	(0.127)
Carbon tax*wheat	0.038	0.084	0.087	0.081	0.092	0.069
	(0.080)	(0.112)	(0.129)	(0.131)	(0.129)	(0.134)
Carbon tax*barley	-0.004	0.047	0.072	0.068	0.057	0.058
	(0.082)	(0.116)	(0.133)	(0.135)	(0.134)	(0.139)
Carbon tax*oats	0.020	0.070	0.064	0.064	0.055	0.060
	(0.082)	(0.116)	(0.133)	(0.135)	(0.134)	(0.139)
Carbon tax*soya	-0.076	-0.051	-0.051	-0.061	-0.011	-0.084
	(0.080)	(0.109)	(0.130)	(0.136)	(0.126)	(0.139)
Carbon tax*canola	0.045	0.157	0.209	0.202	0.204	0.203
	(0.082)	(0.116)	(0.133)	(0.135)	(0.134)	(0.139)
R^2	0.28	0.35	0.39	0.41	0.41	0.53
Obs.	1871	1871	1871	1871	1043	605

$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$; Robust standard errors in parentheses.

Table A3.2: First-differenced results with commodity-specific heterogeneity and the natural log of the real value of gross imports as dependent variable. Column (1) includes commodity-year fixed effects. Column (2) maintains commodity-year dummy variables and adds a linear time trend for each commodity-province pair. In column (3) a quadratic time trend is added for each commodity-province pair to the previous specification in column (2), while column (4) incorporates a cubic time trend for each commodity-province pair. Increasing the flexibility of trends helps to address the volatility in the import and export series over time. It also ensures that unobserved events are not attributed to the carbon tax. Finally, columns (5) and (6) are identical to column (2), but restrict the sample to post-2000 and post-2005 respectively. Shortening the sample ensures that the results are robust to any potential structural shifts in BC's agricultural sector that occurred within the last decade. All models include commodity-year fixed effects as well as weather controls.

	(1)	(2)	(3)	(4)	(5)	(6)
Carbon tax*cattle	0.007	0.015	0.039	0.049	0.041	0.082
	(0.118)	(0.163)	(0.193)	(0.194)	(0.199)	(0.199)
Carbon tax*swine	-0.014	-0.051	-0.074	-0.071	-0.063	-0.062
	(0.120)	(0.167)	(0.197)	(0.197)	(0.203)	(0.203)
Carbon tax*sheep	0.030	-0.058	-0.043	-0.049	-0.037	-0.050
	(0.126)	(0.189)	(0.219)	(0.217)	(0.228)	(0.221)
Carbon tax*honey	-0.001	-0.012	-0.015	-0.004	0.014	-0.004
	(0.119)	(0.166)	(0.196)	(0.196)	(0.201)	(0.202)
Carbon tax*floriculture	0.002	-0.007	-0.003	0.000	-0.009	0.008
	(0.118)	(0.163)	(0.193)	(0.193)	(0.198)	(0.199)
Carbon tax*vegetables	0.013	0.017	0.002	0.002	-0.007	0.012
	(0.117)	(0.162)	(0.192)	(0.192)	(0.197)	(0.198)
Carbon tax*fruit & nuts	-0.002	-0.011	-0.019	-0.019	-0.019	-0.021
	(0.118)	(0.163)	(0.193)	(0.193)	(0.199)	(0.199)
Carbon tax*wheat	0.010	-0.149	-0.156	-0.178	-0.248	-0.159
	(0.123)	(0.173)	(0.202)	(0.202)	(0.208)	(0.208)
Carbon tax*barley	0.075	0.205	0.041	0.043	-0.065	0.019
	(0.127)	(0.180)	(0.209)	(0.209)	(0.214)	(0.215)
Carbon tax*oats	-0.224	-0.340	**-0.418***	**-0.432***	-0.359	**-0.482***
	(0.127)	(0.183)	(0.210)	(0.210)	(0.216)	(0.215)
Carbon tax*soya	-0.020	-0.025	-0.078	-0.036	-0.022	-0.024
	(0.126)	(0.168)	(0.203)	(0.209)	(0.203)	(0.217)
Carbon tax*canola	0.030	0.002	-0.003	-0.015	-0.023	-0.017
	(0.127)	(0.179)	(0.209)	(0.208)	(0.214)	(0.215)
Adj. R^2	0.26	0.33	0.36	0.42	0.37	0.44
Obs.	1662	1662	1662	1662	954	550

***$p < 0.001$, **$p < 0.01$, *$p < 0.05$; Robust standard errors in parentheses.

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