Evaluation of CO2 Emissions by Kansas Agribusiness Retailers

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Abstract

Greenhouse gas (GHG) emissions and their negative effect on the environment is a growing concern in the world. It is estimated that agriculture is responsible for 7% of the total GHG emissions in the United States. Currently, environmental policies to regulate GHG are in place in different countries and are expected to increase in the future. The objective of this study was to estimate carbon dioxide-equivalent emissions from eight agribusiness retailers in Kansas. Data consisted of energy inputs from the operation of the agribusiness retailers and the crop land these retailers serve. Carbon emission coefficients were employed to determine carbon dioxide-equivalent emissions associated with each energy input used during their operations. Results suggest that electricity is the largest source of total carbon dioxide emissions from the retail operations followed by diesel fuel, which represents the main source of direct emissions. Nitrogen fertilizers represent the main source of emissions from crop production.
Emissions from the agricultural sector will not be regulated under the current American Clean Energy and Security Act of 2009 but information on their potential carbon footprint is useful knowledge. If agribusinesses were to be regulated, none of the eight retailers have locations that would be subject to the current cap and trade bill passed by the House of Representatives. But, if they were regulated and had to comply, the cost of partially offsetting their emissions by 5 to 20% would be low given estimations of future carbon prices in the literature. Even if agricultural retailers are not directly restricted, they will likely be affected by increases in energy input prices if such legislation is enacted.

Keywords: Agribusiness, climate change, environmental economics

Introduction

Greenhouse gas (GHG) emissions and their possible adverse impacts on the environment is a growing concern in rural America.[1] Agriculture is responsible for 10-12% of total global anthropogenic GHG (Smith et al. 2007). Agriculture is an important sector in the United States economy with approximately 20% of land employed for crop production (EPA 2009). According to the U.S. Greenhouse Gas Inventory Report prepared by the U.S EPA (2009), agriculture accounted for 7 % of total GHG in 2007. In Kansas, the agricultural sector is responsible for 23.1% of the total GHG emissions, which amounts to 1.49 % of the total emissions within the United States (World Resources Institute 2010).

Currently, environmental policies to regulate GHG are in place in different countries. An example of an established GHG cap and trade programs is the European Union Emission Trading Scheme (EU ETS). As legislation continues to address climate change globally, regulations concerning GHG are expected to increase in the future. In the United States, efforts have been made in relation to climate legislation. H.R. 2454, the American Clean Energy and Security Act (Waxman-Markey Bill) of 2009, was passed by the U.S. House of Representatives in 2009. The main objective of this bill is to mitigate climate change by dealing with GHG emissions and renewable energy technology. GHG emissions will be controlled through emission allowances and a cap and trade system will be developed in order to achieve emission reduction goals (83% of 2005 levels) by 2050. Under this legislation a cap and trade system will be established. A government entity will issue a quantity of allowances and requires companies to surrender

[1] There are some scientists and other experts who are skeptical about the causes of climate change and the relative role of anthropogenic GHG. This study assumes that GHG due to human activity has made an impacting contribution to climate change.

allowances equal to the amount of their emissions. This cap and trade program does not directly limit the quantity of emissions. GHG emissions are expected to decrease gradually by lowering the amount of allowances issued by the government over time (U.S. Senate 2009).

Under the HR. 2454 bill the government would distribute allowances and companies will obtain a certain amount of permits. Industries emitting GHG over their allocated allowances will have the opportunity to purchase permits from an open market (e.g., companies with lower emissions and carbon sequestration projects, etc) as an offset.

Covered entities under the H.R. 2454 bill will be any electricity generator, producer, importer, or distributor of fuels whose combustions emit 25,000 Mt CO_2e and other industrial sectors (e.g., petroleum refinery, lime manufacturing and cement production, etc). This is an important number since it sets a threshold level above which companies would become reporting entities and thus their emissions would become regulated. Nonetheless, regardless of the company's nature, it is important to become acquainted with climate legislation.

Awareness of the environmental impact of agriculture and related activities is demanded by the consumer who wants to make informed purchasing decisions and retailers wanting to differentiate their products by offering greener options (Deimling et al. 2008). As Nartova (2008) points out, much progress has been made concerning the initiatives of companies to measure their GHG emissions. The increasing demand on environmental friendly products and production processes increases the need to estimate GHG emissions from the supply chain. Companies might need to start evaluating ways to lessen their emissions and adopt low carbon technologies.

The aim of this study was to evaluate GHG emissions by agribusiness retailers in Kansas and the cost associated with reductions of their current level of emissions. Estimations of GHG emissions are presented as carbon dioxide-equivalent (CO_2e) emissions.[2] Agribusiness retailers are an important business in the rural economy. They provide agronomic, financial credit, energy, feed, and fertilizer inputs to producers. They also provide a variety of agricultural services for their member farmers. These services usually encompass custom machinery operations, agrochemical applications and feed processing. These retail agribusiness firms function not only as input and resource suppliers but also as marketing units for farm products. Many of these retailers are cooperatives that are owned by producers.

Several studies have been conducted to estimate carbon emissions from crop production as well as the impact of climate legislation on farm income. No information is available on the extent of CO_2 emissions emitted by these retailers. This is the first study to document the effect of the proposed cap and trade legislation on rural agribusiness retailers.

Data and Methods

Energy inputs data

Data from 2007 and 2008 was collected for eight agribusiness retailers in Kansas. The retailers' information was kept confidential and was treated anonymously. For this reason they are referred to as Retailers *A, B, C, D, E, F, G* and *H*. Data corresponds to the energy used by office buildings (e.g., electricity), vehicles (e.g., trucks, semi trucks, cars, agronomy equipment and others using energy), grain elevators (e.g., energy, electricity) and other operations.

[2] Often, GHG emissions are reported in terms of carbon dioxide equivalent (CO_2e) emissions. A measure of equivalent emissions of carbon dioxide results in a quantification that includes carbon dioxide and other GHG converted to comparable units of carbon dioxide through their Global Warming Potentials. Global Warming Potential is a measure of the contribution from a ton of a specific gas to global warming compared to one ton of carbon dioxide, over a 100 year period.

The eight retail operations encompass over 100 locations with a grain elevator, fertilizer plant, feed plant or bulk plant. In addition, a crop production component for the crops served by these retailers was included in this study. Data provided by the agribusiness retailers consisted of direct production inputs from the following crops: corn, silage corn, wheat, soybean, double crop soybeans, sunflower, brome-hay and alfalfa-hay.

Carbon dioxide emission factors data

Emission factors are the emissions per unit of energy input and are expressed as equivalents of carbon dioxide. The emission factors used in this study were obtained from different sources in the literature and are shown in Table 1. Emissions can be direct or upstream/indirect emissions.[3]

Table 1. Direct and indirect carbon dioxide emission factors

Electricity and Fuels	Direct	Upstream
	kg CO_2e / unit	kg CO_2e / unit
Electricity (kWh) [a]	---	0.788
Natural Gas (MCF) [b]	55.79	12.61
Propane (gallon)	6.12	1.16
Gasoline (gallon)[c]	8.80	1.98
Diesel (gallon)	10.10	1.58

[a]Emissions from electricity include emissions from the generation of electricity (U.S. Department of Energy 2002) and from the production and transport of fuels employed for electricity generation (West and Marland 2002).
[b] Natural gas and propane factors from Deru and Torcellini (2007).
[c] Direct emission factors for gasoline and diesel are from EPA (2005) and the upstream factors are from Ecoinvent (2009).

[3] Direct emissions are also referred as on-site emissions and upstream emissions are also referred as indirect or off-site emissions.

Direct emissions are those released on-site and are directly related to the use of the energy inputs. Upstream emissions are the emissions released off-site of the retail operation from the production, manufacture or generation of the different energy inputs. Emission factors for the agronomic inputs were obtained from Lal (2004). The emission factor associated with nitrous oxide from nitrogen fertilizer is from the Ecoinvent Center (2009) used by Clayton-Niederman et al. (2010).

Estimation of carbon dioxide-equivalent (CO_2e) emissions

Carbon dioxide- equivalent emissions were calculated from agricultural processes for retail agribusiness firms in Kansas. Emissions quantification in this study includes direct emissions (e.g., fuel combustion, process emissions), upstream emissions which are emissions released off-site of the retail operation (e.g., extraction and refinery of fuels, emission from energy generation, etc) and total emissions (direct + upstream emissions).[4] Carbon dioxide-equivalent (CO_2e) emissions are referred to as carbon emissions or just emissions throughout the remainder of the study.

Emissions from the retail operations were estimated by determining the emissions associated with each energy source (i.e., fuels, gas, electricity) and employing carbon emission factors for both, direct and upstream emissions. That is:

$$CDE_r^D = (E \times EF_E{}^D) + (Gas \times EF_G{}^D) + \sum_i (fuel_k \times EF_i{}^D)$$

$$CDE_r^U = (E \times EF_E{}^U) + (Gas \times EF_G{}^U) + \sum_i (fuel_k \times EF_i{}^U)$$

[4] All the emissions referenced in this study are carbon dioxide-equivalent CO_2e emissions.

where CDE_r^D and CDE_r^U represent direct (D) and upstream (U) carbon dioxide emission (CDE) expressed in tons of CO_2 from the operations of the *r*th retailer (*r* = A, …, H) and *EF* represent the emission factor per unit of input. Emissions from retail operations encompass emissions from the operation of office buildings, stores, grain elevators and equipment to deliver and apply agronomic inputs. These emissions originate from the use of electricity (*E*), natural gas (*Gas*) and each fuel *k* (*k* = gasoline, diesel, propane).

Consequently total emissions are the sum of direct and upstream emissions as follows:

$$Total\ CDE_r = Total\ CDE_r^D + Total\ CDE_r^U$$

$Total\ CDE$ represents the total burden of emissions associated with the operation of the retailers, which is direct (on-site) and upstream emissions (off-site). A similar approach was employed to estimate emissions from the crops served by these retailers.

Estimation of emission reduction costs

The potential cost of emissions reduction was estimated by imposing a price on the carbon dioxide emissions.[5] The cost of the emissions was determined employing projected carbon prices under climate legislation found in the literature. Different scenarios were constructed based on different levels of emission reductions and various estimated future carbon prices. The reduction levels considered in this study were 5%, 10%, 15% and 20% of the total and direct average (2007- 2008) annual emissions. Carbon prices employed were $10, $15, $20, $30 and $50. These

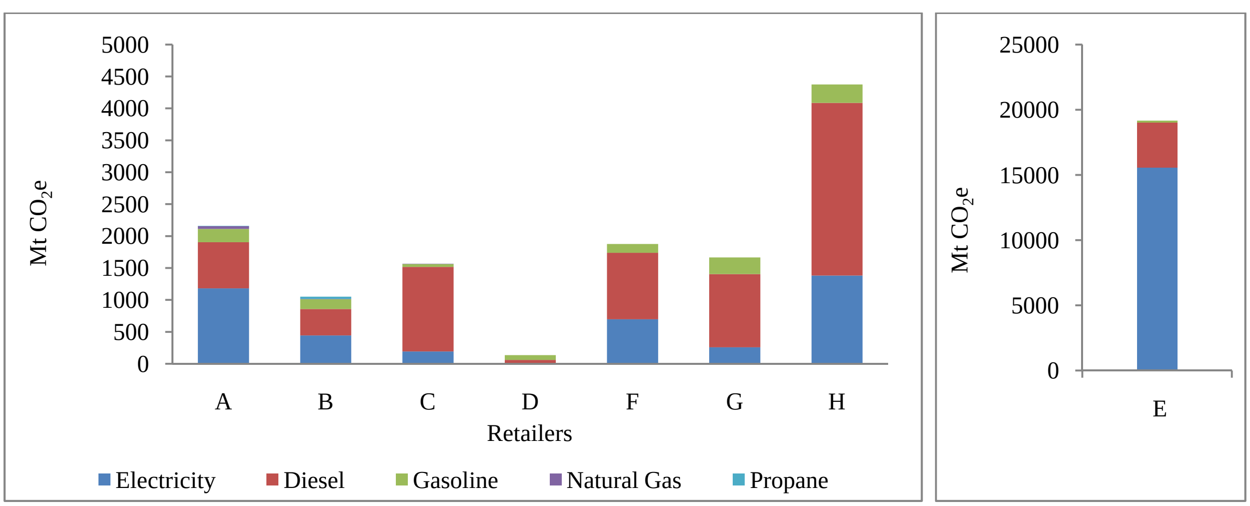
[5] This cost constitutes the cost of buying carbon offsets if these retailers had to comply and surrender carbon offsets by a certain level of their emissions. Voluntary programs of carbon reduction also require that they members offset their emissions above a certain level.

carbon prices are in line with a range of prices used in other studies in the literature. EPA Analysis of the H.R. 2454 estimated carbon prices ranging from $9 to $15 per metric ton in 2012, Babcock (2009) assumes a carbon price of $20 in his analysis of the cost and benefits from climate change policy and the Nicholas Institute of Duke University (NIEPS 2009) considered carbon prices of $15, $30 and $50 per metric ton in their study of the effect of low carbon policy in net farm income.

Results

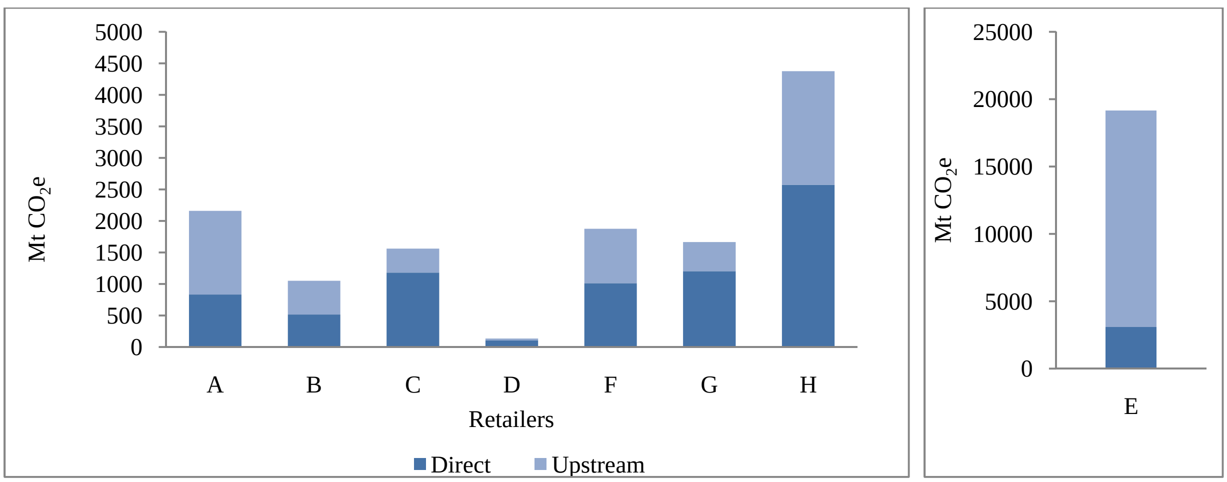
Carbon emissions were calculated for each retailer utilizing energy consumption data. Emissions originate from the use of energy inputs from the operation of the agribusiness retailer location. Retail operations consist of the operation of the main offices, stores, grain elevators, fertilizer plants, fueling stations and other operations. Sources of energy generally used by the retail operations are gasoline, diesel, natural gas, propane and electricity. Sources of total emissions for each retailer are illustrated in Figure 1.

Figure 1. Total carbon dioxide-equivalent emissions by source (average 2007-2008)



In general, the major contributor to total carbon emissions from the retailers' operations is electricity with 61.69 % followed by diesel fuel with 33.91% and gasoline with 4.13%. Conversely, when off-site emissions are not considered and only on-site emissions are accounted for, diesel fuel represents the main source of emissions from the retail operation with 89% followed by gasoline with 10.25%. Direct emissions represent more than half of total emissions for all the retailers except for Retailers A and E for which electricity represents a main source of energy (Figure 2).

Figure 2. Direct and upstream carbon dioxide- equivalent emissions (average 2007-2008)



For Retailer E, upstream emissions represent 84% of the total emissions. The opposite situation is observed for Retailer D where diesel fuel is the main source of total emissions and as a result direct emissions represent 77% of total emissions. Despite the fact that Retailer E has total emissions approximately four times higher than Retailer H, its direct emissions are close to Retailer H's direct emissions. This might have implications with respect to the diversification in the operation of the retailers. Retailers with more locations specialized in grain marketing, retail sales and fuel services tend to use more electricity as a main source of energy. If electricity is the main source of energy, retailers have higher total emissions and lower direct emissions (relative to their size) compared to retailers with a strong agronomic service component and higher diesel fuel use.

The direct, upstream and total emissions for the total retail operations are reported in Table 2. If emissions were to be regulated downstream (final user) it is unlikely that any of the agribusiness firms in this study would be covered. The threshold for a covered entity under the H.R 2454 legislation is 25,000 Mt CO_2e and none of the firms have emissions that exceed this quantity. On-site emissions for the eight retailers average 1,254 CO_2e yr^{-1}. However, each retail operation consists of different individual locations. On average location-specific emissions range from 37 to 401 Mt CO_2e for direct emissions and from 134 to 555 Mt CO_2e for total emissions.

Table 2. Carbon dioxide emission (Mt CO_2e) by agribusiness retail operation

	2007			2008		
Retailer	Direct	Upstream	Total	Direct	Upstream	Total
A	784	1,368	2,153	882	1,284	2,166
B	479	522	1,001	555	547	1,102
C	1,149	359	1,508	1,213	404	1,616
D	105	30	135	104	31	135
E	3,103	16,072	19,176	---	---	---
F	950	714	1,663	1,077	1,013	2,090
G	841	400	1,241	1,566	523	2,089
H	2,617	1,835	4,452	2,527	1,769	4,296

There is a positive relationship between the size of the retail operation in terms of assets value and carbon emissions (total and direct) from the entire operation. A positive relation is also observed between size and average “total” emissions per location. In contrast, a negative relation is observed between retailers’ sizes and average “direct” emissions per individual location.

Larger retailers in this study have more locations and/or higher electricity use and even if total emissions for the total operation are high, direct emissions per location tend to be lower.

Emissions from crop production

The eight agribusiness retailers in this study served approximately one million hectares of conventional and no-tilled corn, grain sorghum, wheat, soybeans, alfalfa-hay, brome-hay and sunflower. Wheat accounts for 68% of the total acreage followed by soybeans with 14% and corn with 9%. The main sources of emissions from the crops served by these retailers are nitrogen fertilizer with 67% and diesel fuel with 28%. Consistent with other studies in the literature nitrogen fertilizer has the largest impact on emissions from the crop production (Clayton-Niederman et al. 2010; Matlock 2009; Saunders 2009; Kim et al. 2008). Fuel related emissions from agronomic practices such as tillage, planting, fertilization, custom chemical applications and harvest are also an important source of emissions. Corn was found to be the crop with the largest emissions with an average emission level of 1.9 Mt of $CO_2e\ ha^{-1}$ and soybeans was the crop with the lowest emissions 0.214 Mt of $CO_2e\ ha^{-1}$. Emissions vary across operations based on their level of energy inputs.

Potential offsets

By quantifying the potential carbon offsets generation by the crop land served by these retailers, it was possible to estimate if they could generate offsets in a sufficient quantity to cover the emissions released from the retail operations. Results suggest that with the potential quantity of carbon offset generated from conservation tillage practices, it is possible to offset all of the emissions released from the operation of the retailers. Even if carbon credit per hectare of no-tilled land is rated very low at 0.2 carbon credit per hectare, the quantity of offset is enough to surpass the current level of carbon dioxide emissions released by these retailers. [6]

For all the retailers, potential offset generation in crop production by their members could cover over 100% of their current level of emissions. Retailer C and D show the highest level of offsets above their emissions. These retailers serve a larger acreage of crops relative to their size when compared with the rest of the retailers.

Consequently, if agribusiness retail operations become regulated it is possible for their members to generate carbon offsets in a sufficient amount to cover carbon burdens at the retail level. However, these operations are not vertically integrated and thus the members are not obliged to surrender offsets for the emissions at the retail operation. But in the event that agribusiness operations were required to hold carbon offsets it may be possible that the members choose to partially or totally supply the amount set by law.

Emission reduction cost

Once the retailers are aware of their level of emissions, actions could be taken to address areas where emissions can be abated. Actions taken to reduce or offset emissions by purchasing carbon credits in the market could result in additional costs for the retailers. To assess the cost of emission reductions, the cost of carbon dioxide emissions was estimated under different reduction levels and carbon prices. This cost can also be seen as the cost incurred if these retailers had to hold carbon permits by a certain level of their emissions under a regulatory cap and trade program or under a voluntary reduction program.

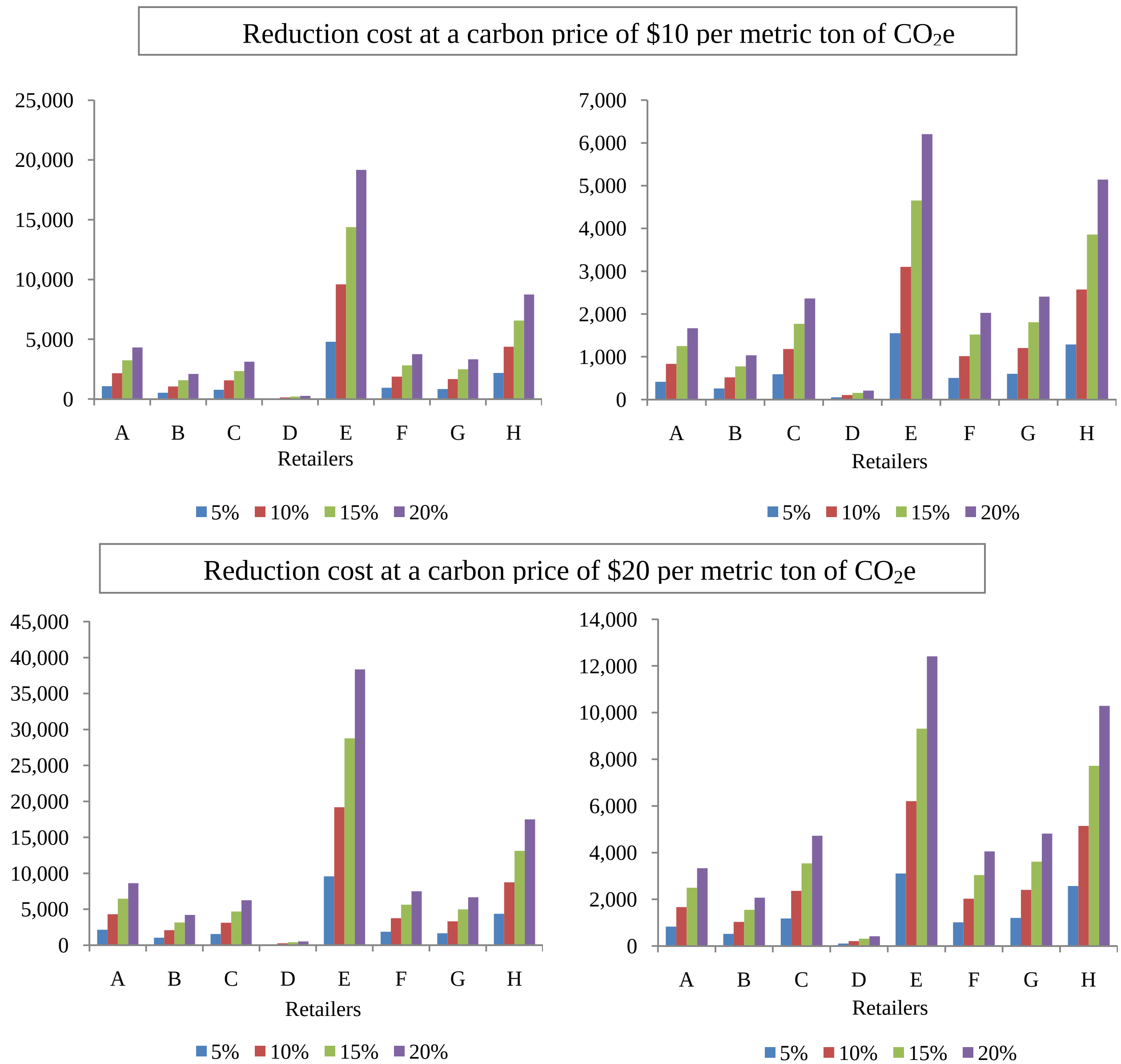
[6] Currently, under the Chicago Climate Exchange (CCX), no tilled land accounts for 0.5 to 1.48 carbon credits per hectare depending on the geographic zone.

Results of the potential emission reduction costs for two possible carbon prices are displayed in Figure 3. Under the most pessimistic scenario if retailers were to reduce their total emissions by 20% at a carbon price of $50, then the reduction cost ranges between $1,347 (for Retailer D) to $95,877 (for Retailer E). For the rest of the retailers, the cost is in average $20,000. In contrast, if total emissions were to be reduced by 5% at the same carbon price, costs would be around $5,000 except for Retailer E and H who have costs of approximately $24,000 and $11,000, respectively. For the same scenario, when emission reductions are calculated on direct emissions instead of total emissions, the cost for Retailer E is drastically reduced by approximately 67%. For the rest of the retailers, the change is smaller especially for those retailers who use diesel and gasoline as their main sources of energy. Retailer E shows this pattern because electricity is its main source of energy and as previously discussed, electricity-related emissions are produced off-site and thus are not considered a source of direct emissions for this study. When carbon prices are $10, costs are small under the levels of direct emissions reduction. For a reduction in direct emissions of 20%, costs range from $209 to $6,000.

If reductions are calculated using total emissions as a base line, cost could be significantly higher than the reductions when direct emissions are considered as a base line. Direct emissions are those emissions directly related to the use of energy inputs by the retailers and therefore the retailer has more control over them. It is reasonable to think that if a company desires to reduce their emissions by a certain level, they do so by taking their on-site emissions as a base line.

In order to assess the magnitude of the emissions reduction cost, it is important to compare this cost with their current level of operational cost to determine if they represent a significant quantity compared to the operational cost of the retailers. No information to that extent is available.

Figure 3. CO_2e emission reduction costs (US$) at different reduction levels



To the left reductions in total emissions and to the right reductions in direct emissions.

There exist different alternatives to emission reductions. These alternatives include increasing the efficiency of energy use and exploring alternative sources of fuels such as renewable sources of energy and bio-fuels. Climate legislation is expected to incentivize companies toward more environmentally sustainable systems of production as the development of new clean technologies takes place and new forms of renewable energy become available. However, these reduction alternatives could also have a cost associated with their implementation.

Based on the cap and trade bill passed by the House of Representatives, energy end-users (retailers) would not be required to offset their emissions. However, the emissions from producers and providers of several of the energy inputs employed by these retailers would be regulated if this legislation were enacted. Thus, it is very likely that the cost imposed on energy generators and suppliers will be passed onto the energy consumers in the form of higher input prices.

Conclusions

This study sheds light on a current topic that has raised concerns over the last several years not only in the scientific community but also in the political environment and society in general. Air pollution originating from the combustion of fossil fuels has been a subject debated in the United States House of Representatives and legislation was passed to mitigate GHG emissions and to increase energy efficiency. A cap and trade program will be established and carbon dioxide emissions will be restricted in the near future if this bill becomes law. Even though agriculture is not covered under the current legislation, primary energy suppliers would likely be constrained.

Consequently, agriculture as an end energy user will most likely be affected indirectly through input price increases. Therefore due to the significance of agricultural retailers in

Kansas, it is important to assess how they might be affected by the present climate legislation passed by the U.S. House of Representatives.

Carbon dioxide-equivalent emissions were calculated for the operation of eight agribusiness retailers in Kansas. Electricity was found to be one of the largest sources of total emissions from the operation of the retailer firms. Fuels used for vehicles, farm equipment and transportation of inputs and outputs also represented a significant source of total emissions and the main source of emissions when only direct (on-site) emissions are considered.

None of the eight retailers had locations that could be subject to the current cap and trade bill passed by the House of Representatives. The largest amount by retailer was less than 20,000 metric tons of CO_2e. The main location of that retail cooperative is similar in size to retailers of a comparable or smaller size. Thus, it is unlikely that local agricultural retailers will be subject to the proposed cap and trade legislation proposed by Congress. In the case that agribusiness retail operations were to be regulated and would have to comply with carbon offsets by a certain level of their emissions, the incurred cost by the retailers in this study would be low based on estimation of future carbon prices in the literature.

With the acreage under no-till served by the retailers it was possible to estimate the potential carbon offsets from carbon sequestration. The quantity of carbon offsets able to be generated due to conservation tillage from crop land could offset all of the emissions released by the retail operations. Producers have the opportunity to generate additional income by providing carbon offsets. In the event that these retailers were required to surrender carbon offsets, the members could supply the amount of carbon offsets demanded.

Even though it is not possible that these agribusiness retailers will be subject to a cap and trade policy considering the current amount of carbon emissions they generate, changes could be made in an effort to lessen emissions. Carbon regulation could have an effect on decisions of inputs usage by the firms' operations as well as the allocation of land to different crops by their members.

The retail operations in this study are heterogeneous, they differ in size and in the services they provide. Total emissions vary across firms given the differences in their input mix. For that reason the findings in this study may not apply to other retailers especially to larger vertically integrated retailers.

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