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THE IMPACT OF THE FEDERAL CARBON TAX ON THE COMPETITIVENESS OF CANADIAN INDUSTRIES

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Executive Summary

With Canada's federal carbon tax set to reach $50 per tonne in 2022 it is often argued that Canadian businesses will become less competitive as a result of higher energy costs. For this reason, firms may relocate to countries where climate-change policies are less stringent—a phenomenon known as carbon leakage. This report examines the extent to which concerns over competitiveness pressures from the carbon tax are valid for Canadian industries and which sectors are at the greatest risk of experiencing carbon leakage.

This analysis uses the latest Input-Output (IO) tables from Statistics Canada for 2015 to estimate the short-term impacts of an economy-wide $50 carbon tax on domestic commodity prices and the production costs of different sectors of the economy in Canada. Full cost pass-through is assumed along the value chain. We find that as a result of a $50-per-tonne carbon tax four industries—petroleum and coal product manufacturing; agricultural chemical manufacturing (pesticide, fertilizer and others); electric power generation, transmission and distribution; and basic chemical manufacturing—will face unit production cost increases of more than 5% in the short-run. These four sectors account for 3% of the national output.

Forty industries including oil and gas extraction, cement and concrete product manufacturing and primary metal manufacturing, which account for nearly 20% of Canada's output, would see their production costs increase by more than 1%. The cost increase for the remaining 71 sectors of the economy is, on average, 0.6%. We estimate the production cost increase for the whole economy (all industries combined) in the short run would be 2.4%.

In the second part of the analysis, we measure trade exposure for industries to help identify the sectors that will face the most competitiveness pressures from the added costs resulting from the carbon tax. Trade exposure influences the extent to which sectors are (or are not) able to pass cost increases on to their customers. The aerospace product and parts manufacturing sector, which accounts for approximately 0.6% of the national output in 2015, is the most trade-exposed sector. This means that firms in this sector are unable to easily pass the added carbon-tax costs on to their customers. Electronic product manufacturing is the second most trade-exposed sector, followed by motor vehicle manufacturing, coal mining, and pulp, paper and paperboard mills.

In the third section, we combine these two dimensions—cost increases from the carbon tax and trade exposure—to identify the sectors that may face the most competitiveness pressures as a result of the carbon tax. We find that 13 industries accounting for 7.3% of national output are exposed to competitiveness pressures in the short run. Specifically, the petroleum and coal product manufacturing sector, which accounts for approximately 0.8% of the national output, will see an estimated cost increase of 25% from a $50 carbon tax and is very exposed to competitiveness pressures. Agriculture and chemical manufacturing (pesticide, fertilizer, and others) is another sector that may be affected by the imposition of a carbon tax. Similarly, many manufacturing sectors including basic chemical manufacturing, primary metal manufacturing, cement and concrete product manufacturing, miscellaneous chemical product manufacturing, and non-metallic mineral product manufacturing will be negatively affected. For instance, the tradable basic chemical manufacturing sector would see a production cost increase of 5.7% in the short term. Similarly, a highly tradable primary metal manufacturing would face a 3.6% increase in production cost. Competitiveness pressures will also be significant for oil and gas extraction and pulp, paper, and paperboard mills, among others. It should be noted that the effect upon competitiveness will be mitigated in the long run as a result of adjustments caused by technological progress and the evolution of the industrial structure.

In response to these concerns, the federal government has designed an output-based pricing system (OBPS) with the intent of limiting the harm to sectors exposed to trade and competitiveness pressures. However, whether it succeeds in doing so will depend on how firms respond, and whether the compensation scheme is sufficiently sensitive to trade exposure. While the cost pass-through as a result of the carbon tax will be mitigated for sectors under the federal OBPS, we show that the reduction in competitiveness pressures will not be as large as the tax rebate, and for some firms it may not be reduced by much at all. We also note that additional research on the OBPS is needed once data becomes available.

Overall, the impact of the carbon tax will vary by sector. Sectors that are more trade exposed are less likely to pass cost increases to consumers. These sectors (and the firms within them) have to absorb the added cost, which results in lower profits, undermined competitiveness, and loss of investment. Consequently, the carbon tax would likely have a significant impact on the decisions about locating facilities by tradable carbon-intensive sectors in Canada. Policy makers need to recognize that a $50-per-tonne carbon tax comes with serious competitiveness risks for many energy-intensive and trade-exposed Canadian industries.

Introduction

Economists consider carbon taxes to be efficient (least costly) instruments for reducing greenhouse gas (GHG) emissions, but concerns have been expressed about their possible negative impacts on industries as a consequence of the loss of competitiveness on international markets.

In early 2019, the federal government implemented a price on emissions of carbon dioxide as part of their strategy to try and meet their target for Canadian GHG emissions by 2030.[1] The policy imposes an emissions price in two forms. Small emitters pay a carbon tax on fuels which then funds rebates to households. Large emitters pay a fee on emissions that exceed a threshold based on the firm's output and each sector's average emission intensity. The federal carbon-tax rate will rise from $20 a tonne in 2019 to $50 in 2022 and will be imposed on provinces that do not have a carbon-pricing system that meets the federal benchmark.

Given that the United States, Canada's major trading partner, does not have a comparable[2] carbon-pricing system in place, competitiveness pressures can arise for emission-intensive and trade-exposed sectors (EITE), with a specific risk of capital relocating to the United States or other jurisdictions without carbon taxes to avoid the extra cost. Migration of economic activity and investment (and the emissions associated with them) from Canada to other jurisdictions with less stringent climate policies—known as "leakage"—will harm economic growth at home and partially reduce the impact of Canadian emission reductions on total global emissions.

This publication investigates to what extent these concerns are valid for Canada and whether they justify changes in the existing carbon-pricing plan. In the first section of the paper, we use an Input-Output (IO) model to estimate the short-term effects of an economy-wide $50-per-tonne carbon tax on domestic commodity prices and the production costs of different sectors of the economy in Canada. We have used the latest *Supply and Use Tables* based on 2015 data produced by Statistics Canada for this analysis

1. Canada has set a 2030 target of reducing GHG emissions by 30% from 2005 levels.

2. The United States does not have a federal carbon-pricing system. It has two regional pricing initiatives with less stringent scope and prices (TD Economics, 2016)

(Statistics Canada, 2018). The impact of a carbon tax, which in the beginning applies to the most emission-intensive sectors, transmits through the whole economy as a result of the interactions among different sectors. Even if a specific sector is not directly using fuels, it uses fuels indirectly through its intermediate inputs, which contain energy and carbon-dioxide emissions.

The IO model allows us to evaluate both direct and indirect interactions and interdependencies among different sectors of the economy; however, it does not embed responses to price changes. It allows us to trace the potential cost impact of a carbon tax being introduced uniformly across all sectors in proportion to the degree of direct and indirect greenhouse-gas emissions in each sector's supply chain, based on the assumption of full cost pass-through. (Appendix A presents the methodology used in this analysis.) We do not account for subsequent behavioural changes in response to higher energy-input prices such as input substitutions, technology adoption, or production process changes. By not incorporating such substitutions our analysis overstates the price impacts of the carbon tax. On the other hand, since the model freezes capital and other inputs at current levels it may understate the potential leakage effects and impacts on domestic incomes. The reader should therefore keep in mind that these are only short-run response estimates, but that they also indicate the nature of long-run adjustments that will follow. Despite these limitations, our analysis is still instructive for identifying the particular sectors that will be most vulnerable to carbon-tax-induced price hikes.[3]

The implied counterfactual in our analysis is the absence of a carbon tax. In reality, if a pricing system were not implemented but the government aimed to achieve equivalent emission reductions an alternative regulatory system would be needed, which would likely have even greater impacts on competitiveness. Consequently, while we are evaluating the impact upon competitiveness of a carbon tax, it should not be assumed that a regulatory alternative would not have similar or larger effects.

The second section of the paper examines trade exposure—the extent to which sectors are (or are not) able to pass cost increases on to their customers. Price-taking industries that are exposed to global competition from imports or exports are least able to pass higher costs induced by the carbon tax down the value-chain to consumers. To preserve

3. Several studies have used IO models to evaluate the impact of a carbon tax: Mongelli, Tassielli, and Notarnicola, 2009; Morgensten, Ho, Shih, and Zhang, 2004; Symons, Proops, and Gay, 1994; Cornwell and Creedy, 1996. For more work on carbon pricing in the Canadian context, see Debson, Winter, and Boyd, 2019; Ecofiscal, 2015, 2016; McKitrick, 2016; and Wood, 2018.

market share, such firms must absorb the increased carbon-tax costs or risk being priced out of the market. This, however, drives down their rate of return to capital and will affect their future employment and investment levels.

The third section combines the two dimensions examined—carbon cost increases and trade exposure—to identify the sectors that may face the most competitiveness pressures from the carbon tax.

In response to competitiveness concerns associated with the federal carbon tax, the government has implemented tax exemptions for EITE sectors. These take the form of an exemption threshold below which firms do not have to pay the charge on emissions. We analyze the effectiveness of the proposed system for mitigating competitiveness pressures in section 4 and Appendix B.

Finally, in section 5 we make some general observations on the steps necessary to predict the long-term impacts of the carbon tax, especially in the presence of trade competition from countries not implementing the same policy.

Overall, we find that, as a result of a $50-per-tonne carbon tax, four industries—namely, petroleum and coal product manufacturing; agricultural chemical manufacturing (pesticide, fertilizer and others); electric power generation, transmission and distribution; and basic chemical manufacturing—will face the largest cost increases, which we estimate to be more than 5% in the short run. These four sectors account for 3% of the national output. Forty industries including oil and gas extraction, cement and concrete product manufacturing, and primary metal manufacturing—which account for 19.7% of Canada's output—would see their cost increase by more than 1%. The cost increase for the remaining sectors of the economy (71 sectors) is, on average, 0.6%. We estimate the input-cost increase for the whole economy (all industries combined) in the short run would amount to 2.4%. Because of limitations of IO modeling, in some respects the actual production-cost impacts would likely be smaller than shown here as our analysis has not accounted for input substitution, innovation, changes to production methods, or the effects of recycling the collected revenue to the households. Also, by assuming capital and labour are fixed we have not taken into account the disinvestment and leakage effects that could amplify the impact on domestic investment and employment. Overall our estimates are likely upper-bound estimates.

Combining estimates of cost increases with information about the trade exposure of each industry reveals that 13 industries that account for 7.3% of national output are exposed to competitiveness pressures in the short-run (which we define rigorously later in section 3 of the paper). Several manufacturing sectors, including petroleum and coal product manufacturing, basic chemical manufacturing, agricultural chemical manufacturing, primary metal manufacturing, cement and concrete product manufacturing, and miscellaneous chemical product manufacturing, are identified as sectors where concern about competitiveness are substantiated. Competitiveness pressures will also be significant for oil and gas extraction and pulp, paper and paperboard mills, among others. It should be noted that the concern about competitiveness will be mitigated in the long run as a result of adjustments caused by technological progress and the evolution of industrial structure.

1. Impacts on Domestic Commodity Prices and Industries

1.1 Input-output analysis

Input-Output analysis is based on the observation that every sector of the economy uses inputs produced by other sectors, while at the same time producing outputs that other sectors use. The inter-relations can be pictured using two matrices: a "Use" matrix and a "Supply" matrix. Suppose there are three sectors in an economy, an energy sector *E*, and two materials-producing sectors *M1* and *M2*. Also suppose there are five inputs to production, capital (*K*), labour (*L*), energy (*E*), and materials (*M1*, *M2*). There is also a household sector (*H*) that supplies labour and capital while using some of each input. The use and supply matrices might look like this:

	USE				SUPPLY			
	E	*M1*	*M2*	*H*	*E*	*M1*	*M2*	*H*
K	1	3	2					6
L	1	2	3					6
E	1	2	1	4	8	0	0	
M1	3	1	2	3	0	9	0	
M2	2	1	2	5	0	0	10	

The energy sector *E* uses inputs as shown down the first column of the Use matrix and produces output as shown in the first column of the Supply matrix. Specifically, it uses 1 unit each of capital, labour, and energy, plus 3 units of *M1* and 2 units of *M2* and produces 8 units of energy. The inputs to the *M1* and *M2* sectors are shown in the second and third columns of the Use matrix. Household demand is shown in the fourth column of the Use matrix.

The economy is balanced when supply equals demand in each sector. In the capital market, adding up across the first row of the Use matrix shows that the economy uses 6 units of capital, which balances the household supply of 6 units as shown in the Supply matrix. Labour demand also adds up to 6 units, matching the supply from households. Likewise the last three rows of the Use matrix add up horizontally to the supplies indicated in the Supply matrix.

We have described these input-output flows in unspecified "units" but suppose they represent value-added and are measured in dollars. Then by introducing prices we can identify additional conditions that ensure financial closure of the economy, namely that every sector must balance its budget. Suppose every price is equal to one dollar. The *E* sector earns $8 on its outputs and spends the identical amount on its inputs (as can be seen by adding up the first column of the Use matrix). Similarly the *M1* and *M2* sectors earn, respectively, $9 and $10 and spend the same amounts on inputs. The total demand for capital and labour (6 units each) yields $12 in earnings for the household, which covers the amount spent by the household as shown in the fourth column of the Use matrix. Thus budgets are balanced across the economy.

Two obvious omissions in our model are the government and the foreign-trade sector. Also, none of the sectors compete directly with each other, since each input in the Use matrix is supplied by only one producing sector. If we introduced a trade sector, for example, all three producers might split market share with it, with households importing goods and producers exporting. In Appendix A, we present a more complete version of the IO model in algebraic terms and show the solutions mathematically in the form of equations that define the economic equilibrium.

If, in our simple example, we introduce a tax on energy equal to 100% of the current price, which must be paid by the purchaser of the energy, we can see at a glance how it will initially affect each sector. In the first instance, total costs for *E* would rise from 8 to 9 (12.5%), for *M1* from 9 to 11 (22%), for *M2* from 10 to 11 (10%), and for households from 12 to 16 (33%). Hence, the tax falls disproportionately hardest on *M1* and the household sector. This does not reflect the final adjustment however, because we have not accounted for the disposition of the tax revenue ($8) and we have not accounted for the price and quantity changes that must occur.

If full cost pass-through happens, the price of energy will rise 12.5%, the price of *M1* will rise 33%, and the price of *M2* will rise 10%. The household will also demand higher payment for capital and labour to compensate for the higher cost of living. Meanwhile, the government will use the tax revenue for some purposes: it might give it all to the household, or it might purchase some inputs and give them away, or it might rebate some to the producers. All these changes would initially throw each sector off its balanced budget, so market prices and quantities would have to adjust until each market comes back into equilibrium at the new prices. In order to predict these subsequent adjustments we would require a tool called a Computable General Equilibrium model that embeds demand and supply elasticities and solves for the closure of the economy after the introduction of the tax. While such models exist we will confine our attention to the first-round changes computable using the IO matrices. We will comment on the steps necessary to predict the full equilibrium responses to the carbon tax, especially in the presence of trade competition from countries not implementing the same policy.

1.2 Short-term impacts of the federal carbon tax

This section presents estimates of the short-term impacts on commodity prices and industry production costs associated with an economy-wide carbon tax of $50 per tonne, based on an IO analysis using the most recent Use and Supply matrices (based on 2015 data) for the Canadian economy produced by Statistics Canada (Statistics Canada, 2018). Table 1 shows the percentage increase in commodity prices associated with the carbon tax for the 30 most heavily affected commodities. As expected, the commodity-price changes would be large for several carbon-intensive refinery products. In response to the carbon tax of $50 per tonne, commodities such as diesel and biofuel diesels and gasoline will experience price increases of 22.5% and 18.5%, respectively. Electricity ranks ninth with an estimated price increase of 6.7%, followed by steam and heated or cooled air or water, and agricultural chemicals. Natural gas liquids and related products will experience a price increase of about 4.8%. Overall, out of 236 commodities in the economy, 73 commodities would experience a price increase of approximately 1% or more.

Table 2 shows the percentage increase in production costs for the 30 most heavily affected industries coupled with the industries' share of Canada's Gross Value Added (GVA).[4] As shown, petroleum and coal-product manufacturing tops the list with an estimated cost increase of 25% resulting from the $50 carbon tax (per dollar of output). This industry accounted for 0.8% of Canada's Gross Value Added (GVA) in 2015. Agricultural chemical manufacturing ranks second with an estimated input-cost increase of 8.5%. Electric power generation, transmission and distribution; basic chemical manufacturing; and air transportation occupy ranks three, four, and five, with estimated cost increases of 6.8%, 5.6% and 3.8%, respectively. Primary metal manufacturing, which accounts for approximately 0.6% of the GVA, ranks sixth with an estimated cost increase of 3.6%. Overall, four industries (that account for 3% of the GVA) would see their input costs increase by more than 5% and 40 industries would see them increase by more than 1%.

4. GVA corresponds closely with GDP. The difference between the two is equal to taxes minus subsidies on products.

Table 1: Estimated percentage increase in commodity prices per $50/ton carbon tax for the 30 commodities most heavily affected

Rank	Commodity	Change in price (%)
1	Coal	171.89
2	Natural gas	112.10
3	Crude oil (including synthetic) and bitumen	41.85
4	Diesel and biodiesel fuels	22.52
5	Gasoline	18.42
6	Other fuels	18.07
7	Other refined petroleum and coal products	13.04
8	Petrochemicals	7.54
9	Electricity	6.63
10	Steam and heated or cooled air or water	5.18
11	Chemical fertilizers, pesticides and other agricultural chemicals	4.83
12	Natural gas liquids and related products	4.81
13	Truck transportation services	3.17
14	Water transportation services	3.15
15	Other basic chemicals	2.80
16	Other miscellaneous unwrought non-ferrous metals including alloys and scrap	2.77
17	Air transportation services	2.75
18	Custom work services for forestry	2.75
19	Ferrous and non-ferrous metal castings	2.70
20	Fuel wood	2.60
21	Mineral and oil and gas exploration	2.47
22	Cement, ready-mixed concrete and concrete products	2.47
23	Logs, pulpwood and other forestry products	2.46
24	Bauxite, aluminum oxide and aluminum products including alloys	2.43
25	Wood pulp	2.34
26	Unwrought precious metals including alloys and gold as store of value	2.23
27	Iron and steel basic shapes and ferro-alloy products including scrap	2.11
28	Basic and semi-finished products of non-ferrous metals and alloys (except aluminum)	2.07
29	Support services for forestry	2.02
30	Iron and steel pipes, tubes and rolled and drawn steel products	1.98

Source: Statistics Canada, 2018; calculations by authors.

Table 2: Estimated percentage increase in production costs per $50/ton carbon tax for the 30 industries most heavily affected and their share of Gross Value Added (GVA)

Rank	Industry code	Industry	Change in production cost(%)	Share of the GVA (%)
1	BS32400	Petroleum and coal product manufacturing	24.76	0.80
2	BS32530	Pesticide, fertilizer and other agricultural chemical manufacturing	8.45	0.11
3	BS22110	Electric power generation, transmission and distribution	6.76	1.88
4	BS32510	Basic chemical manufacturing	5.62	0.28
5	BS48100	Air transportation	3.77	0.48
6	BS33100	Primary metal manufacturing	3.57	0.61
7	BS48300	Water transportation	3.50	0.10
8	BS48400	Truck transportation	3.33	1.07
9	BS21100	Oil and gas extraction	3.04	2.67
10	BS11300	Forestry and logging	2.75	0.21
11	BS32730	Cement and concrete product manufacturing	2.69	0.20
12	BS325C0	Miscellaneous chemical product manufacturing	2.60	0.40
13	BS327A0	Non-metallic mineral product manufacturing*	2.54	0.13
14	BS32210	Pulp, paper and paperboard mills	2.43	0.29
15	BS23E00	Other activities of the construction industry	2.37	0.16
16	BS11500	Support activities for agriculture and forestry	1.97	0.11
17	BS11A00	Crop and animal production	1.93	1.37
18	BS48200	Rail transportation	1.90	0.49
19	BS21210	Coal mining	1.76	0.09
20	NP81310	Religious organizations	1.65	0.17
21	BS32100	Wood product manufacturing	1.63	0.48
22	BS23C10	Transportation engineering construction	1.63	0.50
23	BS31160	Meat product manufacturing	1.51	0.30
24	BS21230	Non-metallic mineral mining and quarrying	1.49	0.47
25	BS221A0	Natural gas distribution, water, sewage and other systems	1.46	0.29
26	BS21300	Support activities for mining and oil and gas extraction	1.43	0.82
27	BS11400	Fishing, hunting and trapping	1.37	0.10
28	BS32220	Converted paper product manufacturing	1.36	0.17
29	BS31110	Animal food manufacturing	1.35	0.08
30	BS32620	Rubber product manufacturing	1.35	0.09

Note: * except cement and concrete products.
Source: Statistics Canada, 2018; calculations by authors.

These 40 industries account for 19.7% of Canada's output in 2015. The cost increase for the remaining sectors of the economy (71 sectors) is, on average, 0.6%. It is important to note that the results presented in table 2 assume no input substitution or behavioural change at any level and it therefore yields upper-bound estimates of total costs.

Overall, the introduction of a uniform $50-per-tonne carbon price will lead to an increases in production costs throughout the economy that will eventually feed through to final consumer prices. Based on equation (18) in Appendix A, the overall impact of the carbon tax on final consumer prices (without any behavioural adjustments) is to increase them by about 2.4%.

2. Trade Exposures of Canadian Industries

This section measures trade exposure for industries to help identify the sectors that will face the most competitiveness pressures from the added carbon cost. Trade exposure for a given sector is defined as the sum of the sector's imports and exports divided by the sum of the sector's production and imports (Ecofiscal, 2015; European Commission, 2009). A sector with a trade exposure of zero thus has neither imports nor exports. A sector with a trade exposure of 100% exports all the goods it produces (if any). Table 3 shows the 30 industries with the highest trade exposure along with the industries' share of Canada's Gross Value Added (GVA).

In general, higher values indicate more heavily traded industries. As shown, the aerospace product and parts manufacturing sector, which accounts for approximately 0.6% of the national GVA in 2015, has the greatest trade exposure. This means that firms in this sector are unable to easily pass the added carbon costs on to their customers. Electronic product manufacturing is the sector with the second greatest trade exposure, followed by motor vehicle manufacturing (82.3%), coal mining (77.4%), and pulp, paper and paperboard mills (75.9%).

Overall, sectors in table 3 that have greater trade exposure are less likely to pass carbon cost increases to consumers. In this case, these sectors (and the firms within them) have to absorb the added cost, which results in declining profits for the firms and thereby undermined competitiveness.

Table 3: Trade exposure for the 30 industries most heavily affected and their share of Gross Value Added (GVA)

Rank	Industry code	Industry	Trade exposure (%)	Share of the GVA (%)
1	BS33640	Aerospace product and parts manufacturing	96.6	0.56
2	BS334B0	Electronic product manufacturing	91.4	0.31
3	BS33610	Motor vehicle manufacturing	82.3	0.47
4	BS21210	Coal mining	77.4	0.09
5	BS32210	Pulp, paper and paperboard mills	75.9	0.29
6	BS31170	Seafood product preparation and packaging	75.7	0.07
7	BS33410	Computer and peripheral equipment manufacturing	75.5	0.03
8	BS335A0	Electrical equipment and component manufacturing	75.0	0.19
9	BS33630	Motor vehicle parts manufacturing	74.7	0.47
10	BS33100	Primary metal manufacturing	74.5	0.61
11	BS33300	Machinery manufacturing	73.0	0.80
12	BS33650	Railroad rolling stock manufacturing	69.4	0.04
13	BS33620	Motor vehicle body and trailer manufacturing	66.8	0.06
14	BS32620	Rubber product manufacturing	65.3	0.09
15	BS21100	Oil and gas extraction	65.1	2.67
16	BS21230	Non-metallic mineral mining and quarrying	62.1	0.47
17	BS32510	Basic chemical manufacturing	61.8	0.28
18	BS325C0	Miscellaneous chemical product manufacturing	61.4	0.40
19	BS32540	Pharmaceutical and medicine manufacturing	60.6	0.28
20	BS33900	Miscellaneous manufacturing	58.8	0.24
21	BS21220	Metal ore mining	58.3	0.73
22	BS31A00	Textile and textile product mills	57.4	0.07
23	BS33520	Household appliance manufacturing	55.0	0.01
24	BS31130	Sugar and confectionery product manufacturing	51.8	0.07
25	BS32220	Converted paper product manufacturing	51.1	0.17
26	BS327A0	Non-metallic mineral product manufacturing*	50.7	0.13
27	BS33200	Fabricated metal product manufacturing	49.8	0.83
28	BS32610	Plastic product manufacturing	49.7	0.46
29	BS32530	Pesticide, fertilizer and other agricultural chemical manufacturing	49.4	0.11
30	BS33690	Other transportation equipment manufacturing	47.5	0.08

Note: * except cement and concrete products.
Source: Statistics Canada, 2018; calculations by authors.

3. Which Sectors Are Most Exposed to Competitiveness Pressures?

In this section, we combine the cost increase estimates from section 1.2 with the information about trade exposure of each industry from section 2 to identify the sectors where concerns about competitiveness may be substantiated. There is no precise cut-off in terms of what production cost increase is large enough to induce firms to relocate to other jurisdictions. We categorize sectors as "more exposed to competitiveness pressures" if they have both a cost increase of greater than 2% and a trade exposure greater than 10%.[5] Using this criteria, in table 4 we show industries that are more exposed to competitiveness concerns given a $50-per-tonne carbon tax. The third column in the table displays the increase in production costs for the sectors (that is, the carbon cost associated with a $50-per-tonne carbon tax as a percentage of the GVA). The fourth column shows the extent of the sectors' trade exposure, and the fifth column shows the industries' share of Canada's Gross Value Added (GVA). Note that increases in production costs should be examined together with trade exposure in order to evaluate the overall impact on competitiveness.

As shown, the petroleum and coal product manufacturing sector, which accounts for approximately 0.8% of the national GVA, is one of the sectors exposed to competitiveness pressures. In particular, this sector, which is also exposed to trade, will see an estimated cost increase of 25% as a result of the $50 carbon tax. Agriculture and chemical manufacturing (pesticide, fertilizer, and others) is another sector affected by the imposition of a carbon tax. Similarly, many manufacturing sectors, including basic chemical manufacturing, primary metal manufacturing, cement and concrete product manufacturing, miscellaneous chemical product manufacturing, and non-metallic mineral product manufacturing, will be negatively affected. Pulp, paper and paperboard mills, oil and gas extraction, and air transportation, and others are also affected industries.

5. These thresholds parallel some papers in the literature: for instance, Grover, Shreedhar, and Zenghelis (2016) used the 2% threshold in the context of increased carbon cost and the European Commission (2009) used the 10% threshold for trade exposure. Using the 2% threshold for increased carbon cost is a more conservative approach than that taken by some other papers in the literature: for instance, Gonne (2010) used the 1% threshold for the cost increase.

Table 4: Sectors of which the competitiveness is affected

Industry code	Industry	Increase in production costs (%)	Trade exposure (out of 100)	Share of the GVA (%)
BS32400	Petroleum and coal product manufacturing	24.76	33.06	0.80
BS32530	Pesticide, fertilizer and other agricultural chemical manufacturing	8.45	49.43	0.11
BS32510	Basic chemical manufacturing	5.62	61.75	0.28
BS48100	Air transportation	3.77	39.77	0.48
BS33100	Primary metal manufacturing	3.57	74.52	0.61
BS48300	Water transportation	3.50	43.53	0.10
BS48400	Truck transportation	3.33	18.92	1.07
BS21100	Oil and gas extraction	3.04	65.06	2.67
BS32730	Cement and concrete product manufacturing	2.69	14.10	0.20
BS325C0	Miscellaneous chemical product manufacturing	2.60	61.36	0.40
BS327A0	Non-metallic mineral product manufacturing*	2.54	50.65	0.13
BS32210	Pulp, paper and paperboard mills	2.43	75.92	0.29
BS23E00	Other activities of the construction industry	2.37	11.19	0.16

Note: * except cement and concrete products.
Source: Statistics Canada, 2018; calculations by authors.

As some analyses in the literature have used a different threshold for what production cost is large enough to put a sector at a risk of leakage (1% or 5%), we have considered different production-cost thresholds and presented the results associated with those thresholds in table 5 (Ecofiscal, 2015; Gonne, 2010). This table presents the number of industries and their share of Canada's GVA whose competitiveness will be negatively affected under different production-cost thresholds.

Table 5. Number and share of the most affected industries given different production-cost thresholds

Number of industries	Share of the GVA (%)	Experience an increase in production costs greater than x%
3	1.2	x = 5%
31	15.3	x = 1%

Note: The identified sectors also have a trade exposure greater than 10%.
Source: Statistics Canada, 2018; calculations by authors.

As shown, under the 5% threshold we find the competitiveness of three sectors that account for 1.2% of the national economy will be significantly affected in the short run. Under the 1% threshold, 31 sectors accounting for 15.3% of the economy will face potentially significant effects upon competitiveness.

Overall, the introduction of a $50-per-tonne carbon price will result in concerns about the competitiveness of various industries in the short run. The sectors included in table 4 are at greatest risk for carbon leakage. As previously stated, carbon leakage will harm economic growth in Canada and counteract reductions in greenhouse-gas emissions at the global level. Clearly, the competitiveness concerns will be mitigated in the long run by adjustments as a result of technological progress and the evolution of industrial structure.

4. Accounting for the Effects of the Federal Output-Based Pricing System

The intent of the federal Output-Based Pricing System (OBPS) is to limit the harm to sectors exposed to trade and competitiveness pressures. Whether it succeeds in doing so will depend on how firms respond, and whether the compensation scheme is sufficiently sensitive to trade exposure.

Under the OBPS, each emitting firm is charged the tax rate per tonne of emissions but large emitters only pay on their emissions above a threshold, a scheme that can be thought of as a rebate based on their relative emission intensity. The rebate works as follows. All firms are grouped by industry or sub-industry and their emissions intensity (emissions per unit of output) is calculated by facility. The average emissions intensity is calculated across all emitters in the group and is then multiplied by a threshold parameter (0.9, currently). Then a facility's tax compensation is determined by this formula: *threshold parameter* × *average emissions intensity* × *facility's output*. Most firms will receive a compensation payment less than its tax bill: only firms with emissions intensity well below the industry average would get a net payment.

The chief form of competitive pressure is an increase in production costs in Canada relative to other countries. Because a carbon tax means input costs go up, every firm's supply curve will shift to the left, which means its selling price will rise and it will thereby lose market share. The OBPS compensation will partly offset this but not by an amount corresponding to the fractional reduction in the firm's tax bill. The reason is that firms make supply and pricing decisions based on their marginal costs (the cost of the last unit produced) whereas the OBPS rebate will be a lump-sum transfer for most firms, and therefore will not have much effect on pricing at the margin. The marginal cost for firms of the emissions price can be quite variable even within a sector (because emissions characteristics can be quite variable). As a result, the extent to which a firm is protected from concerns about competitiveness by the OBPS rebate will vary a lot among firms within a sector. Those firms with high marginal emissions will face the biggest competitiveness concerns even if they do not have the highest average emissions.

In Appendix B (p. 27), we show that the factor determining by how much the OBPS reduces competitiveness risk is determined, not by the difference between a facility's emissions intensity and the industry average, but by the difference between its *marginal* emissions and the average emissions intensity for the industry. This can vary considerably from firm to firm even when all firms in a sector face the same degree of competitiveness risk. Also, the degree of competitiveness protection for a facility within a sector is determined, not by the relative level of trade exposure of that facility, but by its marginal emissions rate, which is unrelated to the market characteristics. Hence, there can be a situation in which some firms in a trade-exposed sector get an ineffective level of protection for their market share, even though all firms get a rebate and some even pay a negative net tax.

We illustrate these issues with a numerical example in Appendix B in which a sector consisting of seven firms gets 90% of its carbon-tax revenues back under the OBPS, but the cost pass-through (and thereby the risk to competitiveness) is reduced on average by only 53%, and four of the seven firms get less than 50% competitiveness protection. In order to apply the analysis to the Canadian economy, we would need detailed estimates of marginal emission functions for all the firms in the sectors listed in table 2. This information is not available, so all we can do at this point is note that, while the cost pass-through as a result of the carbon tax will be mitigated for sectors under the federal OBPS, it will not be reduced by a factor as large as the tax rebate, and for some firms it may not be reduced by much at all.

5. Projecting the Final Effects of the Carbon Tax

In order to translate the price changes in table 2 into final output changes we would need several additional lines of information.

Emission characteristics

For each sector, the price change will be attenuated somewhat by the OBPS (where applicable) but, as explained above, the offset will be variable based on the emissions characteristics of each firm, and will not necessarily correlate with competitiveness risk.

Demand and supply elasticities

Price changes will translate into equilibrium output changes based on the demand and supply elasticities of each sector's market. A demand elasticity of, say, 0.5 means that the percentage decrease in the quantity demanded equals 0.5 times the percentage increase in price. Since all price changes are positive, all changes in quantity demanded initially will be negative, but in markets with low elasticities the changes may be small. Additionally, some changes will be reversed as a result of substitution effects. As energy gets more expensive, energy-intensive sectors will shrink and their demand for inputs (including labour) will decline, but at the same time they will substitute away from energy and employ more of other inputs in order to minimize cost increases.

Labour market elasticities

The overall reduction in output in energy-intensive sectors will reduce labour demand and force down wages and salaries. As workers exit for other sectors, employment will expand in less energy-intensive sectors. Once all displaced workers are rehired elsewhere, some sectors may end up with a larger work force, albeit at lower salaries.

There is some empirical evidence on the magnitude of employment shifts based on the experience in British Columbia (Yamazaki, 2017; Yip, 2018; Azevedo, Wolff, and Yamazaki, 2018). For instance, Yamazaki (2017) presents estimates of the empirical impacts of the BC carbon tax when it was first implemented at $10 per tonne. The sectors near the top of table 2 experienced relatively large employment reductions (10% to 40%) but sectors further down the list experienced net employment gains, with the gains eventually more than offsetting the losses. The largest employment growth occurred in the retail sector and in the public sector (specifically health care). In general, the tax falls most heavily on sectors that tend to be capital-intensive rather than labour-intensive so, as long as labour can transition between sectors, overall employment effects will be muted. But it is noteworthy that incomes tend to be lower in labour-intensive sectors compared to capital-intensive ones, so overall income is expected to fall. It is also noteworthy that the net gains reported in Yamazaki (2017) depend on the public sector expanding to accommodate additional workers. This may not be sustainable in the national version since the OBPS returns a large fraction of the revenue to the emitting sectors in what is effectively a lump-sum rebate, which does not increase labour demand.

Capital flows

Another important adjustment factor is the change in the relative rates of return to capital in Canada and the United States. Investment flows across the border are responsive to expected profits. The carbon tax will fall disproportionately heavily on capital-intensive sectors and it is to be expected that investors will reduce capital allocations in Canada relative to the United States until rates of return are equalized. These effects can be large and cause far-reaching effects on future economic growth. Unfortunately, there is no guidance on this type of potential impact in the modeling work done by Environment Canada, since they rely on the EC-Pro model, which assumes that capital is fixed and cannot move across Canadian regions or across the border (Böhringer, Rivers, and Yonezawa, 2016).

Conclusions

The introduction of a $50-per-tonne carbon price will result in concerns about competitiveness for many Canadian industries in the short-run. We find that as a result of a $50-per-tonne carbon tax, four industries, namely, petroleum and coal product manufacturing; agricultural chemical manufacturing; electric power generation, transmission and distribution; and basic chemical manufacturing will face the largest cost increases, which are estimated to be more than 5% in the short run. Forty industries including oil and gas extraction, cement and concrete product manufacturing, and primary metal manufacturing—which account for 19.7% of Canada's output—would see their cost increase by more than 1%. The cost increase for the remaining 71 sectors of the economy is, on average, 0.6%. We estimate the input cost increase for the whole economy (all industries combined) in the short run would amount to 2.4%.

When considering which sectors will be at the greatest risk for cabon leakage from the carbon tax—through examining both carbon cost increases and trade exposure—we find that 13 industries that account for 7.3% of national GDP are exposed to competitiveness pressures and thereby carbon leakage in the short run. Specifically, the petroleum and coal product manufacturing sector, which accounts for approximately 0.8% of the national output, is one of the sectors that is most exposed to competitiveness pressures. Agriculture and chemical manufacturing (pesticide, fertilizer and others) is another sector affected by the imposition of a carbon tax. Similarly, many manufacturing sectors including basic chemical manufacturing, primary metal manufacturing, cement and concrete product manufacturing, miscellaneous chemical product manufacturing, and non-metallic mineral product manufacturing will be negatively affected. It should be noted that the competitiveness concerns will be mitigated in the long run as a result of adjustments caused by technological progress and the evolution of industrial structure.

In response to these concerns, the federal government has designed an output-based pricing system (OBPS) with the intent of limiting the harm to sectors exposed to trade and competitiveness pressures. However, whether it succeeds in doing so will depend on how firms respond, and whether the compensation scheme is sufficiently sensitive to trade exposure. While the cost pass-through as a result of the carbon tax will be mitigated for sectors under the federal OBPS, the reduction in competitive pressure will not be as large as the tax rebate, and for some firms it may not be reduced by much at all.

The reality is that a $50-per-tonne carbon tax will fall disproportionately heavily on capital-intensive sectors and therefore we expect to see investors shift capital allocations from Canada to the United States. This movement of capital from Canada to the United States has the potential to counteract reductions in greenhouse-gas emissions globally and has far-reaching effects on future economic growth. It is time for policy makers to acknowledge that a $50-per-tonne carbon tax comes with serious competitiveness risks for many energy-intensive Canadian industries that are integral to Canada's economy.

Appendix A. Input-Output Methodology and Dataset

Methodology

In order to examine the impact of the carbon tax on different industries, we use an input-output framework covering the entire economy. The input-output (IO) model that we present here is built using the latest supply-use tables (formally referred to as input-output tables) based on 2015 data produced by Statistics Canada (Statistics Canada, 2018). These tables represent a detailed snapshot of all economic activity as well as the interlinkages among various economic sectors. They provide a coherently integrated picture of how commodities are produced and used in the economy. The supply table displays the supply of products produced from imports and domestic production. The use table shows the use of products by domestic industries (intermediate consumption) and final users (capital formation, exports, final consumption by households, general government, and non-profit institutions serving households [NPISH]). The use table also shows the value added by industries. The data reported in the supply-use tables are in dollar values, which implicitly contain both price and quantity components.

Our focus is on the short-term impact, that is, before firms and final users are able to significantly change their behaviour by input switching, consumption switching, or technological innovation in response to the carbon tax. Full cost pass-through is assumed along the value chain, taking the carbon content of different fuels into account.

We adapted fairly standard input-output conventions for the notation (*e.g.*, Miller and Blair, 2009) and followed the methodology developed by R.D. Morgenstern and colleagues (2004). Assume we have j industry and i commodity in the economy, where $j = 1, 2, ..., n$ and $i = 1, 2, ..., m$. Let x_j be the output of industry j, and the input of labour, capital, and m types of intermediate commodities be $(l_j, k_j, u_{1j}, u_{2j}, ..., u_{mj})$.

We define "use matrix" as:

(1) $U = [u_{ij}]$,

where u_{ij} is the value of purchases of intermediate commodity i by industry j. Note that supply-use tables distinguish between industries and commodities. A given industry may produce more than one commodity and a given commodity may be produced by several industries.

We also define matrix B by dividing the intermediate inputs reported in the use table by total output by industry as:

(2) $B = [b_{ij}]$, where $b_{ij} = \frac{u_{ij}}{x_j}$,

The column j of matrix B represents the value of inputs of each commodity per dollar's worth of industry j's output.

With this definition, the use matrix is simply given by:

(3) $U = B\hat{x}$,

where $\hat{x}$ is a diagonal matrix of industry outputs.

The matrix showing how industries make commodities is termed the supply matrix and is denoted by V:

(4) $V = [v_{ji}]$, where v_{ji} is value of commodity i that is produced by industry j.

From the supply matrix, total output of any industry is found by summing over all commodities produced by that industry; therefore:

(5) $x_j = \Sigma_i v_{ji}$

Similarly, using the supply matrix, total output of any commodity can be found by summing over all industries that produce the commodity. We denote total output of commodity i from all industries by q:

(6) $q_i = \Sigma_j v_{ji}$

Now, let's consider the total supply and demand of each commodity. The suppliers of a given commodity i are the domestic suppliers and imports. The users of the commodity i are the industry intermediate purchasers of intermediate products and the final users—households, government, investors, and net exporters. Therefore, the supply and demand balance of commodity i is given by:

(7) $q_i + IM_i = \Sigma_j u_{ji} + C_i + G_i + I_i + EX_i \quad i = 1, 2, \ldots, m$,

where q_i and IM_i denote domestic suppliers and imports for good i and C_i, G_i, I_i, and EX_i denote consumption, government, investment, and exports for commodity i, respectively.

We define total final demand, E_i, as the demand for domestic commodity i by the final users (households, government, investors, and net exporters). This corresponds to a familiar definition for gross domestic product, *GDP*, which equals:

(8) $GDP = C + G + I + EX - IM$

Therefore, for a given commodity i, the supply-demand balance can be rewritten as:

(9) $q_i = \sum_j u_{ji} + E_i$.

Using equation (3), we can write equation (9) in a vector form for all m commodities:

(10) $q = Bx + E$.

This equation contains commodity output (q) on the left-hand side and industry output (x) on the right-hand side. Following the literature (Miller and Blair, 2009; Morgenstern, Ho, Shih, and Zhang, 2004), we therefore use the data in the supply matrix to transform industry outputs, x, to commodity outputs, q.

Define $d_{ji} = \frac{v_{ji}}{q_i}$, so that d_{ji} denotes the fraction of total commodity i that was produced by industry j. The matrix form of these commodity output proportions becomes:

(11) $D = [d_{ji}]; \; D\hat{q} = V$,

where $\hat{q}$ is a diagonal matrix of commodity outputs. The D matrix shows the proportion of each commodity that is produced by each industry.

Using both equations (5) and (11), we therefore relate industry outputs x, to commodity outputs, q, by:

(12) $x = Dq$.

With the above elements, we now rewrite equation (10), which is the supply and demand balance for all m commodities:

(13) $q = Bx + E = B(Dq) + E$.

This can be rewritten as:

(14) $q = (I - BD)^{-1}E$,

where I is the identity matrix. $(I - BD)^{-1}$ is known as the Leontief inverse, which connects commodity final demand to commodity output. Specifically, the Leontief inverse matrix indicates that to produce a vector E of final demand commodities, the economy must produce a vector q of gross output of commodities. In particular, if we want the economy to produce an extra unit of good *i* for final users, this formulation indicates the additional outputs, such as additional electricity, coal, crude oil, natural gas, and so on, that must be produced (Morgenstern, Ho, Shih, and Zhang, 2004).

The vector of additional output needed for one unit of *i* is given by:

(15) $\Delta q_i = (I - BD)^{-1} i_i$,

where i_i is a vector with a 1 in the i^{th} element, and zeros everywhere else.

Now we can estimate the total additional carbon emissions (both direct and indirect) that results from one more unit of good *i* using the following formula:

(16) $\Delta CarbonEmission_i = \theta_{coal}\, e_{coal}\, \Delta q_{i,coal} + \theta_{oil}\, e_{oil}\, \Delta q_{i,oil} + \theta_{gas}\, e_{gas}\, \Delta q_{i,gas}$,

where θ represents the carbon content per BTU of fuels (coal, oil, and gas) and *e* represents the energy content (BTU) per \$ of fuels. Note that, following Morgenstern, Ho, Shih, and Zhang (2004), we include only primary fuels in the above equation and exclude additional electricity or additional refined petroleum products because they are secondary products. For instance, it is the production of electricity that generates carbon emissions and that is already captured by the gas, coal, and oil components in the equation. Similarly, refined petroleum products such as motor gasoline, jet fuel, kerosene, and so on are all captured at the crude oil stage.

We assume that a carbon tax at rate \$*t* per ton will increase the cost of, and therefore the price of, *i* by an amount:

(17) $\Delta p_i = t\, \Delta CarbonEmission_i$.

The total cost to final users is the change in price multiplied by the quantity purchased of each product:

(18) $\Delta COST^{FinalUsers} = \Sigma_i\, \Delta p_i\, E_i$.

Similarly, the total increase in current costs to industry *j* per dollar output is:

(19) $\Delta COST_j = \Sigma_i\, \Delta p_i\, B_{ij}$.

It is important to note that equation (19) calculates the increase in production costs for different industries as a result of carbon tax. As in this model we have not accounted for offsetting carbon tax revenues that might be recycled back into affected industries or any behavioural changes, these estimates of total costs cannot be interpreted as net costs for industries. In other words, these estimates can be interpreted as upper-bound estimates of total costs.

Data

This analysis uses the latest supply-use tables (at basic prices) based on 2015 data produced by Statistics Canada. These tables represent a detailed snapshot of all economic activity as well as the interlinkages among various economic sectors. The classification systems in the supply-use tables in Canada are hierarchical with four levels of aggregation that cover the same contents with varying degree of details. We have used the L-61 level of data (medium level), which covers 111 industries and 236 commodities. Interindustry flows are expressed on monetary value. The emission coefficients and the energy prices for primary fuel energy sources are reported in table A1.

Table A1. Energy price and emission coefficient

Energy source	Price (CA$ per MMBtu)	Emission Coefficient (KG CO_2 per MMBtu)
Crude oil	9.83	77.34
Natural gas	2.70	59.19
Coal	3.00	102.34

Source: Bank of Canada, 2015; US EIA, 2015; IPCC, 2006; Natural Resources Canada, 2016, 2018.

Appendix B. Facility Responses to the Output-Based Pricing System (OBPS)

Under the Output-Based Pricing System (OBPS), the facility profit function is:

$$\pi = py - c(w, y) - \tau e(y) + \tau \hat{e},$$

where π is profits, τ is the carbon tax per tonne of emissions e, w is the input cost vector, y is output, emissions $e(y)$ depend only on y for a given type of technology and $\hat{e}$ is the emissions credit (compensation). It is calculated using:

$$\hat{e} = 0.9 \times \bar{z} \times y$$

where $\bar{z}$ is the industry average emission intensity $\frac{\bar{e}}{\bar{y}}$.

The firm chooses output y to maximize profits. This occurs where the derivative of the profit function with respect to y equals zero. If we assume that each firm is too small to affect the average emissions intensity across the sector, the derivative is written:

$$\frac{\delta\pi}{\delta y} = p - c_y - \tau(e_y - 0.9\,\bar{z}) = 0,$$

where c_y means marginal cost of output and e_y means marginal emissions of output.

If the emissions tax was zero this would reduce to $p = c_y$, or price equals marginal cost, which is the usual definition of a supply curve. With the emissions tax in place, the derivative rearranges to:

$$p = c_y + \tau(e_y - 0.9 \times \bar{z}),$$

which implies the supply curve shifts up the price axis by the amount $\tau(e_y - 0.9 \times \bar{z})$. If there were no OBPS compensation, this term would reduce to $\tau \times e_y$, and the firm's supply curve would shift up by that amount.

If the term $(e_y - 0.9 \times \bar{z})$ is positive, the supply curve shifts up, and if it is negative it shifts down. Therefore, the competitive pressure faced by a firm will depend on how its marginal emissions (e_y) compares to the average emissions intensity in the industry $\bar{z}$ $(\times\, 0.9)$.

To explore this outcome further, we will construct a numerical example (table B1). Suppose an industry consists of seven facilities, and the emissions e from each facility is given by the formula:

$$e = ay^{\beta}.$$

Note that if $\beta > 1$ this is a convex function so emissions go up at an increasing rate as output goes up. In table B1 we choose seven pairs of values for α and β and seven output levels, and list the implied levels of output and emissions, and the emissions intensities. Then, assuming the tax is $20 per tonne we use the industry average emissions intensity (0.138) to compute the gross tax bill, the compensation (rebate), the net tax bill and the percentage rebate. For the industry as a whole the tax rebate is equal to 90% of the taxes paid. Note that three of the seven firms get a net tax rebate.

The last three columns of the table B1 show the competitiveness effects under the OBPS. Column e_y shows the marginal emissions of output for that firm (the amount by which emissions increase if output goes up by one unit). The next column to the right, labeled "Shift Term", shows ($e_y - 0.9 \times \bar{z}$). Note that this is positive for all seven firms, even the three that get a net tax rebate. In other words, even though they get more back in rebates than they pay in taxes, their marginal operating costs still rise and their supply curve shifts up.

Table B1: Numerical Example of Output-Based Pricing System (OBPS)

α	β	Facility output (units)	Facility emissions (tonnes)	Emissions intensity	Gross tax bill ($)	Rebate ($)	Net tax bill ($)	Rebate (%)	e_y	Shift term	CPF (%)
0.6	1.80	1,000	151	0.151	3,014	2,475	539	82	0.27	0.15	46
1.8	1.60	900	96	0.107	1,919	2,228	−309	116	0.17	0.05	73
0.27	1.90	1,400	256	0.183	5,129	3,465	1,664	68	0.35	0.22	36
0.58	1.75	1,200	142	0.118	2,838	2,970	−132	105	0.21	0.08	60
0.6	1.85	800	141	0.176	2,818	1,980	838	70	0.33	0.20	38
0.4	2.10	300	64	0.212	1,274	743	531	58	0.45	0.32	28
2.2	1.50	1,800	168	0.093	3,360	4,455	−1,095	133	0.14	0.02	88
		7,400	**1,018**	**0.138**	**20,352**	**18,317**	**2,035**	**90**			**53**

The final column is called the Competitiveness Protection Factor (CPF). It represents the percentage difference between e_y and $(e_y - 0.9 \times \bar{z})$. If there were no OBPS compensation, the firm's supply curve would shift upwards by $\tau \times e_y$. With the compensation, it shifts upward by $\tau(e_y - 0.9 \times \bar{z})$. The CPF represents the percentage reduction in the magnitude of the shift in the supply curve.

We can see that the CPF is much smaller than the percentage rebate, averaging 53% rather than 90% across the whole industry. The CPF varies from a low of 28% to a high of 88% so it is quite variable from firm to firm. Of particular importance here, the variation in the CPF is entirely due to the variation in marginal emissions, not variations in competitiveness pressure. All seven firms in the sector are, presumably, facing the same degree of international competitiveness risk, which is why they qualify for the rebate scheme. But not every firm gets the same level of competitiveness protection. The risk to market share comes from the size of the supply curve shift, not from the percentage of tax rebate and, for four of the firms, the rebate system offsets less than half of the competitiveness effect.

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