

Impact of Carbon Price Policies on U.S. Industry

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Executive Summary

As the United States moves toward mandatory action on climate change, an important consideration is the potential for new policies to cause significant declines in some domestic industries, with corresponding increases in imports and production elsewhere in the world. This is especially the case if the policy is unilateral, without a corresponding effort from U.S. trading partners.

This possibility gives rise to two serious concerns:

- potential damage to the domestic economy, especially to the subset of industries that may be vulnerable to unilateral, or near unilateral, carbon mitigation policies; and
- erosion of a domestic policy's environmental benefits if an increase in domestic production costs causes manufacturing to shift to nations that have weaker greenhouse gas (GHG) mitigation policies or none at all.

The effects of a unilateral policy placing a price on carbon dioxide (CO₂) will vary greatly across domestic industries. The industry-level impacts are fundamentally tied to the energy (more specifically, the carbon) intensity of those industries and the degree to which they can pass costs on to consumers of their products (often other industries). The strength of competition from imports and consumers' ability to substitute other, less carbon-intensive alternatives for a given product play crucial roles in determining the ultimate impacts on domestic production and employment.

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The potential economic consequences for U.S. industry are unprecedented in the history of environmental regulation due to the scale of activity affected by a unilateral, economywide CO₂ pricing policy. It would not only have significant direct impacts on coal, and other domestic energy industries, it could adversely affect the competitiveness of a number of large energy-intensive, import-sensitive manufacturing industries. Unfortunately, information concerning specific industry-level impacts associated with new carbon mitigation policies is quite limited.

The most common approach to assessing the impact of carbon-control policies is to focus on the long-run impacts, after firms have adjusted by using new energy-efficient technologies and new import patterns have been established. Such analysis, however, fails to capture an important part of the story—the short-run costs that most firms will experience. A chemical or steel plant suddenly faced with higher energy costs cannot immediately or costlessly convert to more energy-efficient methods.

From a policy perspective, the path taken to the long-run outcome is extremely important. A carbon control policy that ignores these short- and medium-term impacts will raise concerns about fairness and will likely be opposed by many stakeholders. Further, the appropriate policy response can change over time; a policy that addresses fairness questions in the initial years may not be appropriate in the future.

We recently examined how a unilateral, economywide CO₂ pricing policy would affect a large set of industries, taking into account the ways that adjustment costs may change over time. To paint a full picture, we employed four different modeling approaches using consistent assumptions in order to consider outcomes along four different time scales:

1. The very short run, where firms cannot adjust prices and profits fall accordingly.
2. The short run where firms can raise prices to reflect the higher energy costs, with a corresponding decline in sales as a result of product or import substitution.
3. The medium run, when in addition to the changes in output prices, the mix of inputs may also change, but capital remains in place, and economywide effects are considered.
4. The long run, when capital may be reallocated and replaced with more energy efficient technologies.

Impacts were measured in terms of costs, profits, employment, and trade effects, assuming a unilateral \$10/ton CO₂ price without any offsetting measures regarding permit allocation or border adjustments and without any stipulated policies by trading partners.

Findings

After examining these different time horizons and impacts, our results yield a number of observations. (For more details, see the tables at the end.)

- **Measured by the reduction in domestic output, a readily identifiable set of industries is at greatest risk of contraction over both the short and long terms.** Within the manufacturing sector, at a relatively aggregated, two- or three-digit standard industrial classification level, the hardest hit industries are: petroleum refining, chemicals and plastics, primary metals, and nonmetallic minerals.
- **Although the short-run output reductions are relatively large in these industries, they shrink over time as firms adjust inputs and adopt new technologies.** The industries that continue to bear the impacts are generally the same ones affected initially, albeit at reduced levels. When measured in terms of reduced profits, the rebound is especially large and, for some industries, virtually complete.
- **Focusing on the nearer-term timeframes, where certain simplifying assumptions enable us to conduct a more disaggregated analysis, we observe that the largest cost increases are concentrated in particular segments of these industries.** Using a broad definition of costs that includes capital inputs, petrochemical manufacturing and cement see very short-run cost increases of more than four percent from a modest charge of \$10 per ton of CO₂, while iron and steel mills, aluminum, and lime products see cost increases exceeding two percent.
- **In the nonmanufacturing sector, we see that although the overall size of the production losses also declines over time, a more diverse pattern applies.** Specifically, the impact on electric utilities does not substantially worsen over time (compared to other industries such as mining, which experiences a

continuing erosion of sales) as broader adjustments occur throughout the economy. Agriculture faces modest but persistent output declines over time, while the service sector is largely unscathed across all timeframes.

- **In terms of employment, short-term job losses are modeled as proportional to those of output.** Over the longer term, however, when labor markets are able to adjust, the remaining, relatively small, losses are fully offset by gains in other industries.
- **Overall, the leakage rate (that is, the rate at which reductions in U.S. emissions is offset by increases in foreign emissions) is estimated to be about 25 percent.** For the three most energy-intensive sectors, chemicals, nonmetallic mineral products, and primary metals, the leakage due to imports and exports is more than 40 percent.

Policymakers have a number of tools at their disposal to address the competitiveness challenges that are likely to accompany a carbon-pricing policy. These options include: weaker overall program targets, partial or full exemption from the carbon policy, standards instead of market-based policies for some sectors, free allowance under a cap-and-trade system, and trade-related policies, including some form of border adjustment for energy- or carbon-intensive goods.

For a more in-depth discussion of policy options, see “Addressing Competitiveness Concerns in the Context of a Mandatory Policy for Reducing U.S. Greenhouse Gas Emissions,” by Richard Morgenstern. Issue Brief # 8 in Assessing U.S. Climate Policy Options, Raymond J. Kopp and William A. Pizer, editors. RFF Report, Nov. 2007.

www.rff.org/Publications/Pages/CPF_AssessingUSClimatePolicyOptions_IB8.aspx

Modeling Results

Short-Run Output Effects

In the short run, producers raise prices to cover the higher unit costs when a price is placed on carbon. Unlike a very-short term effect, which does not allow for behavioral responses by firms or individuals, here customers are able to switch to alternative goods and/or imports, leading to a fall in sales and output. The output decline varies among industries, but it can be

significant for energy intensive industries like petrochemical manufacturing and fossil fuel suppliers (Table 1).

Table 1. Short-Run Time Horizon: Effect of a \$10/ton CO₂ Charge on Output (percent change)

Manufacturing industries	
Food	-0.38
Textile	-1.13
Apparel	-1.03
Wood and furniture	-0.34
Pulp mills	-1.00
Paper mills	-1.08
Paperboard mills	-1.11
Other papers	-0.46
Refining-LPG	-0.68
Refining-others	-0.79
Petrochemical mfg.	-7.65
Other basic inorganic chemical mfg.	-1.92
Other basic organic chemical mfg.	-3.66
Plastics material and resin mfg.	-3.95
Artificial and synthetic fibers, filaments	-1.83
Fertilizer manufacturing	-3.58
Other chemical and plastics	-1.00
Glass container manufacturing	-1.04
Cement manufacturing	-4.06
Lime and gypsum product mfg.	-1.73
Mineral wool manufacturing	-0.97
Other nonmetallic mineral	-0.88
Iron and steel mills, ferroalloy mfg.	-2.06
Alumina refining, primary aluminum	-2.42
Ferrous metal foundries	-0.68
Nonferrous metal foundries	-0.78
Other primary metals	-1.08
Fabricated metals	-0.33
Machinery	-0.76
Computer and electrical equipment	-1.00
Motor vehicles	-1.24
Other transportation equipment	-0.89
Miscellaneous manufacturing	-0.65
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Nonmanufacturing industries	
Farms	-0.56
Forestry, fishing, and hunting	-0.41

Oil mining	-5.09
Gas mining	-6.34
Coal mining	-11.01
Other mining activities	-0.49
Electric utilities (including government enterprises)	-1.35
Gas utilities	-4.95
Construction	-0.42
Trade	-0.16
Air transportation	-1.05
Truck transportation	-0.72
Other transportation	-0.52
Information	-0.13
Finance and insurance	-0.06
Real estate and rental	-0.10
Business services	-0.15
Other services	-0.21
Government excluding electricity	-0.31

Medium and Long Term Output Effects

Over the medium term, firms can adjust their input mix to adapt to higher energy prices, thus reducing their vulnerability to the new tax. At the same time, however, consumers are adjusting their purchases to avoid the higher prices for carbon-intensive products and thus reducing their demands. The cost-reducing effect of input substitution is generally dominant (Table 2). Over time, for all but two manufacturing industries (petroleum refining and fabricated metals), the cost shock of the carbon tax is reduced, and smaller price increases are needed to cover the higher costs of carbon-intensive inputs.

Table 2. Effect on Output of a \$10/ton CO₂ Tax (percent change)

	Short-run partial equilibrium effect only	Medium-run general equilibrium effects with fixed capital	Long-run general equilibrium with reallocation of capital
Manufacturing industries			
Food	-0.38	-0.11	-0.12
Textile	-1.13	-0.51	-0.50
Apparel	-1.03	-0.18	-0.07
Lumber, wood, paper	-0.53	-0.32	-0.32
Petroleum refining	-0.78	-4.72	-5.36
Chemical and plastics	-1.74	-1.11	-1.26
Nonmetallic mineral	-1.20	-0.86	-0.94
Primary metals	-1.57	-1.30	-1.21
Fabricated metals	-0.33	-0.44	-0.43
Transportation equipment	-1.14	-0.35	-0.27
Electrical machinery	-1.00	-0.13	0.08
Other machinery and miscellaneous mfg.	-0.72	-0.50	-0.49
Nonmanufacturing industries			
Agriculture	-0.54	-0.58	-0.68
Coal mining	-11.01	-4.89	-7.85
Oil mining	-5.60	-1.02	-2.09
Gas	-4.95	-5.33	-10.04
Other mining	-0.49	-0.74	-1.06
Electric utilities	-1.35	-1.37	-1.17
Construction	-0.42	-0.32	-0.39
Transportation	-0.67	-1.02	-1.15
Services	-0.17	0.05	0.06

A further metric of importance is the impact on employment. As is the case with output, only for petroleum refining and fabricated metals is the reduction in employment larger in the medium- and long-term horizons compared to the short-run, no-substitution case. Going from the medium to the long run where firms can switch capital, the reduction in employment diminishes in all cases. In two extreme manufacturing cases, apparel and electrical machinery, the medium-run employment reductions turn to gains in the long run. That is, the ability to substitute capital

for the more expensive carbon-intensive inputs in the long run leads to bigger reductions in energy consumption and smaller reductions in labor use.

In the nonmanufacturing industries, we also see a smaller employment impact in the medium run compared to the short run except for two industries, the most interesting being electric utilities, where output falls by 1.4 percent but employment rises by 8 percent in the medium run. Going from the medium to long run, the three fossil-fuel mining industries actually see greater employment losses. That is, users of fuels substitute capital for fuel over the longer term and the demand for coal, oil, and gas falls, leading to lower employment.

Capital use in the long run is driven by two opposing effects. On one hand, outputs from carbon-intensive sectors are diminished, reducing the demand for capital. On the other, there is substitution from expensive energy to cheaper capital, which increases the demand for capital in these sectors. The net effect is negative for all but three manufacturing industries. That is, the reduction in capital demand due to the reduction in output dominates the substitution of capital for energy in most industries. The capital that moves out of the declining carbon-intensive sectors goes to services and, perhaps surprisingly, to the electricity sector. For manufacturing industries, only in the food, apparel, and electrical machinery industries are the long-run demands for capital slightly higher after a carbon tax is in place.

Table 3. General Equilibrium Effects on Employment and Capital of a \$10/ton CO₂ Tax (percent change)

	Employment		
	Short run	Medium run	Long run
Manufacturing industries			
Food	-0.38	0.06	0.08
Textile	-1.13	-0.52	-0.32
Apparel	-1.03	-0.10	0.05
Lumber, wood, paper	-0.53	-0.25	-0.10
Petroleum refining	-0.78	-5.64	-3.86
Chemical and plastics	-1.74	-0.81	-0.47
Nonmetallic mineral	-1.20	-0.67	-0.42
Primary metals	-1.57	-1.10	-0.69
Fabricated metals	-0.33	-0.44	-0.30
Transportation equipment	-1.14	-0.32	-0.15
Electrical machinery	-1.00	-0.05	0.21
Other machinery and miscellaneous mfg.	-0.72	-0.55	-0.33
Nonmanufacturing industries			
Agriculture	-0.54	-0.12	-0.09
Coal mining	-11.01	-8.12	-10.15
Oil mining	-5.60	-2.14	-2.77
Gas	-4.95	-5.71	-9.15
Other mining	-0.49	-0.80	-0.99
Electric utilities	-1.35	8.08	3.52
Construction	-0.42	-0.35	-0.33
Transportation	-0.67	-0.46	-0.34
Services	-0.17	0.18	0.16

Trade Impacts

The trade impacts are displayed in Table 4. National domestic consumption is the sum of consumption by firms, households, and government and is equal to domestic output plus imports less exports. The second column gives the changes in consumption due to a \$10/ton CO₂ tax, while the last three columns present the contributions of the changes in terms of output, imports, and exports. We can see a consistent pattern among carbon-intensive manufacturing industries: a modest increase in imports and a bigger reduction in exports. Overall, the emissions increase in

the rest of the world is 26 percent of the reduction in U.S. emissions as a result of a unilateral U.S. carbon tax. This is a relatively high leakage rate but consistent with other studies.

Table 4. Long-Run Trade Effects of CO₂ Tax on Domestic and Imported Fuels

	Base case domestic consumption* (million \$)	Domestic consumption with CO ₂ tax (% change)	Contribution**		
			Output	Imports	Exports
Manufacturing industries					
Food	5,556	-0.03	-0.12	0.03	-0.06
Textile	1,232	-0.30	-0.45	0.05	-0.11
Apparel	1,605	0.10	-0.05	0.12	-0.02
Lumber, wood, paper	5,006	-0.25	-0.31	0.02	-0.05
Petroleum refining	1,579	-5.88	-5.61	-0.28	0.00
Chemical and plastics	5,569	-0.62	-1.30	0.18	-0.50
Nonmetallic mineral	967	-0.49	-0.91	0.13	-0.29
Primary metals	2,182	-0.66	-1.11	0.16	-0.30
Fabricated metals	2,278	-0.40	-0.43	-0.01	-0.03
Transportation equipment	5511	-0.22	-0.25	-0.02	-0.06
Electrical machinery	3,368	-0.19	0.07	-0.14	0.12
Other machinery and miscellaneous mfg.	7,014	-0.39	-0.47	-0.04	-0.12
Nonmanufacturing industries					
Agriculture	2,452	-0.27	-0.72	0.11	-0.34
Coal mining	253	-17.24	-10.15	-0.44	6.65
Oil mining	1067	-5.51	-1.07	-4.32	0.12
Gas	463	-10.68	-9.50	-1.22	-0.05
Other mining	275	-0.96	-1.03	-0.02	-0.09
Electric utilities	2,344	-1.00	-1.17	0.13	-0.04
Construction	9,936	-0.39	-0.39	0.00	0.00
Transportation	5,352	-0.76	-1.18	0.08	-0.33
Services	80,941	0.05	0.06	0.00	0.01