Does Regulation Kill Jobs?

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Chapter 4

The Employment and Competitiveness Impacts of Power-Sector Regulations

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In the debate over environmental regulations, a principal concern is the potential impact on employment in the more energy-intensive U.S. manufacturing industries. Although the academic literature and agency practice in regulatory impact analyses have estimated the direct effect of manufacturing-sector environmental regulations on employment, these literatures have been largely silent on the indirect effects of power-sector environmental regulations (the exception being general equilibrium analyses of power-sector policies; Rausch and Mowers 2012). Yet the extensive array of power-sector regulations on the horizon could increase electricity rates manufacturing firms face. This would increase domestic production costs, and eventually prices charged to customers must rise, causing a decline in domestic sales as well. This production decline may include, in part, a shift of economic activity and jobs overseas to key trading partners, if they do not face comparable regulation.

This chapter focuses on estimating the magnitude of both gross manufacturing-sector employment impacts and net competitiveness impacts in the power sector under environmental regulations. We define such competitiveness effects as the adverse business impacts related to a domestic regulatory policy in the absence of regulation on international competitors. It is the harm domestic firms bear because they face a higher price on factors of production, in this case electricity, than their foreign competitors, specifically owing to differences in the regulatory regimes faced by firms participating in a given market. Some of these domestic firms have limited pricing power for manufactured commodity-like goods that compete in a global market, and this inhibits their ability to pass through the costs of a domestic regulatory policy.

This definition of competitiveness highlights that a portion of the regulatory impact on U.S. industry is unrelated to foreign trade. Even if all U.S. trading partners were to implement environmental regulations identical to those in the United States, some emission- and energy-intensive firms in the United States could still bear substantial costs. In the face of a new domestic regulatory program, the costs of investing in new technologies to reduce a firm's emissions, along with declines in the consumption and production of emissions- and energy-intensive goods, are distinct from domestic producers losing market share or profits solely because foreign competitors do not face similar regulation. We believe this distinction is important because foreign competition and the loss of jobs overseas are frequently cited in arguments against environmental regulation.

As an illustration of the need for this kind of analysis of power-sector regulatory impacts on manufacturing employment, consider the Environmental Protection Agency's 2011 Cross-State Air Pollution Rule (CSAPR). This rule imposes pollution control requirements on about 3,700 fossil-fuel-fired generating units that could increase the cost of producing electricity.[1] As a part of the rule, the U.S. EPA (2011) published a regulatory impact analysis that characterizes the benefits and costs of the regulation. The U.S. EPA (2011:286) notes, however, that it has "not quantified the rule's effects on all labor in other sectors not regulated by this rule." Although the agency has not quantified the employment impacts beyond the power sector, it recognizes that this is a "notable" impact when describing the overall labor impacts of the regulation:

> We expect ongoing employment impacts on regulated and non-regulated entities for a variety of reasons. These include labor changes in the regulated entities resulting from shifts in demand for fuels, increased demand for materials and the labor required to provide them to operate pollution control equipment, reductions in employment resulting from coal retirements, and reductions in other industries due to slight projected increases in the price of electricity and natural gas. The most notable of the ones we are unable to estimate are the impacts on employment as a result of the increase in electricity and other energy prices in the economy. (U.S. EPA 2011:295)

The empirical methods employed in this chapter could explicitly address this kind of omission in regulatory impact analysis.

Overview of the State of the U.S. Manufacturing Sector

The sensitivity of American manufacturing to energy prices varies across industries because of the significant heterogeneity in the energy required to produce a dollar of output. For example, the manufacturing of hydraulic cement is approximately 100 times more energy-intensive than making cigarettes, and it is about 50 times more energy-intensive than the manufacturing of telephones. The chemicals, primary metals, pulp and paper, and stone, glass, and clay (including cement) industries consume slightly more than half of all energy used in the manufacturing sector (U.S. Energy Information Agency multiple dates). These energy-intensive industries' share of energy in the manufacturing sector has remained fairly steady since the early 1990s, although primary metals (for example, steel, aluminum) have experienced a modest decline, reflecting their declining share of manufacturing output over time. Their shares of the manufacturing sector's production—about 16 percent—have likewise remained steady since the early 1990s (Bureau of Economic Analysis n.d.), and they illustrate the relative energy intensity of their production. The energy-intensive industries' share of employment has followed a similar pattern since the early 1990s, consistently comprising about 20 percent of the manufacturing sector's payrolls (Bureau of Labor Statistics n.d.).

Of energy inputs, electricity expenditures comprise a majority of energy expenditures in the manufacturing sector. In 2001, the mean and median electricity cost share of total energy costs were 0.64 and 0.68, respectively. Eighty-two percent of manufacturing industries had a majority of energy costs coming from electricity expenditures in 2001. Over the past three decades, the energy intensity of the U.S. manufacturing sector has improved, with much of this improvement occurring as a result of the oil shocks–induced price increases in the 1970s and early 1980s. Petroleum consumption in the broader industrial sector peaked in 1979 and fell nearly one-quarter through 2010 even as total industrial production was 75 percent greater in 2010 than in 1979 (Council of Economic Advisers 2012; U.S. Energy Information Administration 2011).

The declining energy intensity of output reflects changing production techniques and innovation in manufacturing. Steel production has shifted from blast oven furnace (BOF) production, which comprised 70 percent of U.S. steel output in 1985, to electric arc furnace (EAF) techniques, which made up 55 percent of production in 2005 (Office of Technology Assessment 1985; U.S. EPA 2007). This transition affects the energy impact of steel production, as BOF allows for cogeneration of heat, whereas EAF requires large amounts of electricity and thus makes it more sensitive to the costs of power-sector regulations. The energy intensity of U.S. aluminum production has declined by 61 percent over the past 40 years, reflecting technological improvements and the growth of the recycling sector, which requires less energy than manufacturing from raw materials (U.S. Department of Energy 2007). The resilience of the paper industry to the energy price shocks of the 1970s and early 1980s reflects its atypical position as a major source of power: the industry fulfills roughly half of its own energy needs via biomass cogeneration. This partially buffers the industry from electricity price shocks and could even yield a benefit if paper mills can sell power to the grid when electricity rates are higher. Cement production has shifted toward dry process cement, which requires less direct energy but more electricity than wet process cement, as the proportion of U.S. kilns using the dry process increased from 38 to 70 percent over the 1975–2001 period (Hanle et al. 2004).

A few snapshots of the energy-intensive manufacturing sector reveal industries that grow slower than the rest of the U.S. economy and, through technological change and competitive pressures, have reduced payrolls over the past few decades. Most energy-intensive industries—iron and steel, aluminum, paper, cement, glass, and industrial chemicals industries—have experienced declines in payrolls on the order of 40 percent or more since 1983 (cement is the outlier, with an increase of 20 percent). This has occurred while some industries—such as iron and steel, glass, and cement—have experienced production increases of 40 percent or more, while other industries—aluminum, paper, and chemicals—have witnessed flat or modest growth in output.

The slow growth in U.S. manufacturing output reflects two phenomena: slow demand growth and increasing international competition. Just as energy-intensive industries responded to high energy prices by economizing on their use of energy in production, downstream users of these industries' goods have found ways to efficiently use less of these energy-intensive inputs in the production of their final goods. Some of this may reflect changes in quality—for example, steel used in automobiles becoming stronger over time—that allows downstream producers to use less of the energy-intensive good. Some of this may reflect opportunities for substitution—for example, aluminum or plastic substituting for steel in automobile manufacture. U.S. energy-intensive manufacturers' share of the domestic market has also declined over time. Although net imports can vary significantly from year to year, they do show an increasing trend in recent years for most energy-intensive industries (United Nations Statistics Division n.d.). Thus, any assessment of the employment and competitiveness impacts in manufacturing should account for the baseline of significantly lower employment levels today than a generation ago and increasing competition from foreign suppliers.

The Impacts of Environmental Regulation on Manufacturing

A substantial research literature has addressed the question of whether and how environmental regulations adversely affect American industry. Studies including Schmalensee (1993), Rutledge and Vogan (1994), Jaffe et al. (1995), and Morgenstern et al. (2001) have all focused on the burden of environmental regulation on industry. Yet, although the overall impact on costs, employment, or production is of interest in its own right, most of the literature has framed the issue in terms of trade competition with other jurisdictions. That is, there is some notion that lowering consumption (and production) of polluting goods may be okay, but simply shifting their production abroad is not. Indeed, much of the current policy debate reflects issues raised by theoretical analyses suggesting that environmental policy could create so-called pollution havens in developing countries: “The conventional wisdom is that environmental regulations impose significant costs, slow productivity growth, and thereby hinder the ability of U.S. firms to compete in international markets. This loss of competitiveness is believed to be reflected in declining exports, increasing imports, and a long-term movement of manufacturing capacity from the United States to other countries, particularly in ‘pollution-intensive’ industries” (Jaffe et al. 1995:133). Evaluating this conventional wisdom requires a careful examination of a simple empirical question: Do firms lose market share in response to domestic environmental policies, either by relocating their manufacturing activity to or by facing lower-cost competition from countries with lax environmental policies?

Addressing this question necessitates an assessment of the broader context about firm location. A variety of factors may mitigate or dominate the effect of environmental regulatory costs in determining manufacturing location decisions. First, the availability of relevant factors of production, such as appropriately skilled labor, natural resources, and capital, can play a more significant role than pollution control costs. Pollution-intensive industries tend to be capital-intensive, so capital abundance in developed countries may outweigh the impacts of environmental regulations (Antweiler et al. 2001). Second, transportation costs may discourage relocation to countries far from the major markets for manufactured goods. Ederington et al. (2005) found that transportation costs diminish the impact of pollution abatement costs on net imports: an industry with high transport costs (for example, at the 80th percentile in the manufacturing sector) experiences a percentage increase in net imports equal to about 20 percent of the impact for an industry with average transport costs (for example, at the 50th percentile in the manufacturing sector). Firms with a significant share of their investments in large, fixed physical structures also appear to move activity less in response to environmental regulations (Ederington et al. 2005). Proximity to firms that produce inputs or purchase outputs—for example, industrial parks and related forms of so-called agglomeration economies—also discourages relocation (Jeppesen et al. 2002). These factors all determine whether an industry is “footloose,” that is, sufficiently mobile that a small change in production costs, such as from an environmental regulation, could drive some firms to relocate to other countries.

Because the most pollution-intensive industries tend to be relatively immobile by these measures of “footlooseness,” the empirical literature typically finds quite limited impacts of environmental regulations on international competitiveness. Levinson and Taylor (2008) showed that U.S. pollution abatement costs in the 1970s and 1980s increased net imports in the manufacturing sector from Mexico and Canada. The estimated increase in net imports from pollution abatement roughly equaled about 10 percent of the total increase in bilateral trade for both Mexico and Canada, suggesting that other factors played much more substantial roles in the evolution of trade among the North American trading partners. An extensive literature on the competitiveness effects of variation in environmental policies across the U.S. states has shown more significant impacts on domestic firm and employment relocation resulting from variation in the stringency of environmental regulations (Greenstone 2002; Henderson 1996). The larger domestic competitiveness impacts may reflect the fact that labor costs and availability of capital do not vary much across the U.S. states and transportation costs are less important, relative to the international context.

In the context of carbon pricing policy in the European Union (EU) and potential carbon pricing in the United States, a wave of papers have addressed the associated competitiveness impacts of climate change policies. Given the prospective nature of these analyses, the scholars have undertaken detailed accounting exercises or employed models to simulate the effects of carbon prices on output and related impacts. The accounting-based papers focus on energy-intensive sectors and infer a percentage cost increase from a carbon price at varying proportions of free permit allocation by using data on average cost, electricity use (assuming some level of pass-through), and direct carbon dioxide (CO_2) emissions. They then make assumptions about demand elasticities to infer changes in production or employment. Reinaud (2005) examined impacts under a €10 per ton CO_2 price (modeled after the EU

Emission Trading Scheme [EU ETS]). She estimated that before accounting for any free allocation, energy-intensive industries would experience cost increases ranging from 1.5 percent for EAF steel to 18.6 percent for cement. Applying her assumptions of price elasticity of demand and maintenance of profitability margins, output declines, ranging from 2.3 percent for EAF steel to 12 percent for BOF steel. McKinsey and Company and Ecofys (2006) performed a similar EU ETS–based analysis at €20 per ton CO_2. When properly scaled to a comparable carbon price, assuming linear costs, the McKinsey numbers are of a magnitude similar to Reinaud's.

Carbon Trust (2008) used a similar approach to that of the Reinaud and McKinsey studies in an evaluation of the UK manufacturing sector. Like McKinsey, the Carbon Trust analysis assumes a €20 per ton CO_2 allowance price modeled on the EU ETS. This carbon price would increase the production costs in lime, cement, and iron and steel by more than 25 percent in the United Kingdom. Aluminum, inorganic chemicals, and pulp and paper would experience cost impacts on the order of 10 percent at €20 per ton.

Ho et al. (2008) used a model-based approach to simulate the output, consumption, and trade impacts of a $10 per ton CO_2 price implemented unilaterally in the United States. They simulated short-term impacts when firms have little opportunity to change production inputs and invest in new, low-carbon capital (in a partial equilibrium analysis) and long-term impacts that account for all adjustments to the CO_2 price (in a general equilibrium model). They found that the CO_2 price drives down manufacturing output by 1.3 percent in chemicals and plastics, 1.1 percent in primary metals, and 0.9 percent in nonmetallic minerals. Slightly more than half of the decline in chemicals and plastics production is offset by an increase in net imports from countries that are not implementing greenhouse gas emission mitigation policies. Primary metals would experience a 0.46 percent competitiveness effect and nonmetallic minerals a 0.42 percent effect. These results show that the reduction in output is represented by a larger drop in domestic consumption than in an increase in net imports.

Employment and Competitiveness: Measures, Data, and Methods

We estimate the impacts of power-sector environmental regulations on manufacturing employment and competitiveness by drawing on the historic effects electricity prices have on these measures. Using regression analysis, we separately estimate the effects of the price of electricity on employment, production, and consumption over the 1986–1994 period for more than 400 manufacturing industries. We then use these statistically estimated relationships to simulate the gross employment effect as well as a measure of the net or competitiveness employment effect of higher electricity rates resulting from new regulations, such as carbon pricing or air quality rules.

Gross employment impacts are of interest in their own right as an important economic indicator of the effect of new environmental regulations. That is, how much does employment change because of a regulation? The analysis is straightforward empirically: we simply estimate the electricity price–employment relationship while controlling for other important factors, as detailed below.

To estimate the competitiveness employment impacts of electricity regulations—that is, the change in employment arising from the lack of similar regulation among our trading partners—we focus on electricity price impacts on production, net imports, and consumption, where we define consumption as production plus net imports. Changes in the consumption of manufactured goods reflect the impact of an environmental regulation that would occur independent of any trade effects. This is not a competitiveness effect. Therefore, we look at the residual effect on production arising from changes in net imports as the competitiveness effect (Aldy and Pizer 2009). Because we can decompose a gross production effect into a net competitiveness effect, we can use the ratio of the competitiveness to gross production effects to adjust the gross effect on employment to estimate the employment competitiveness effect.

We used detailed data from more than 400 industries in the manufacturing sector. For example, our analysis includes 11 classifications within the iron and steel sector. We undertake our analysis with the relevant data in logarithms because these sectors differ vastly in size. Our models estimate and predict changes in percent terms, rather than in actual dollars or jobs, which facilitate comparability even among different-sized sectors. The reported impacts represent percent changes from the respective base levels for each of the more than 400 industries.

We estimate employment, production, and consumption as a function of energy prices and other factors over the 1986–1994 period for more 400 manufacturing industries by using a model of the following form:[2]

$$Y_{it} = \alpha_i + \alpha_t + f(price_{it}; \beta) + \delta' X_{it} + \varepsilon_{it}.$$

In the model, Y_{it} represents an industry and year-specific outcome measure—the natural logarithm of employment, value of shipments, and consumption; the αs are fixed effects for industries (i) and years (t); $price_{it}$ is the natural logarithm of the average electricity cost in 1987 dollars; and X_{it} is a vector of additional determinants of the industry outcome measures, including tariffs and factor intensity variables (to estimate the returns to human capital and physical capital). Table 4.1 presents the summary statistics for the three outcome measures used as dependent variables and all independent variables used to estimate the regression functions (except for year and industry fixed effects).

The key results for our simulation are the estimated functions *f* for each of the different outcome variables. The function of price we specify in our regressions is a piecewise linear spline function that estimates distinct electricity price elasticities for different components of the distribution of industries based on their average energy intensity in the sample period. We focus on a seven-segment spline that estimates electricity price elasticities for industries in the first, second, third, and fourth quintiles of the energy intensity distribution, as well as those in the eighth decile (80th to 90th percentile) and 19th and 20th semi-deciles (90th to 95th percentile and greater than 95th percentile). Aldy and Pizer (2009) provide further details in a technical appendix on the empirical framework.

Table 4.1. Summary Statistics of Variables Employed in Various Regression Models

	Variable	*M* *(SD)*
Dependent variables	ln(employment)	3.09 (1.11)
	ln(value of shipments)	7.76 (1.23)
	ln(value of shipments + net imports)	7.81 (1.19)
Independent variables	ln(electricity price)	0.72 (0.86)
	Ratio of energy costs to value of shipments	0.026 (0.035)
	Average tariff rate (percent)	5.95 (6.12)
	Physical capital intensity	0.58 (0.15)
	Human capital intensity	0.14 (0.069)

Note: Means and standard deviations for 400+ industries over 1974–1994, representing 8,519 observations. Each regression used in this analysis employs one of the dependent variables and includes all independent variables in this table plus year and industry fixed effects. The text describes how electricity prices are specified as a spline function of the energy intensity variable.

The assumption that outcomes depend on prices in a flexible way based on the function *f* is a critical distinction in our analyses. When we estimate the electricity price–employment relationship for the entire manufacturing sector without accounting for the energy intensity of industrial output, for example, we find no statistically meaningful effect. Decomposing this relationship as a function of energy intensity helps to illustrate the interesting variation across the manufacturing sector. For example, one might expect that firms in relatively energy-lean textiles could respond differently to a 10 percent increase in electricity prices than relatively energy-intensive steel firms. Our analysis allows us to estimate the energy price-competitiveness measure relationships for distinct components of the manufacturing sector as a function of their energy intensity.

Results of Empirical Analysis

Figure 4.1 presents the distribution by energy intensity of the nearly 450 industries in the manufacturing sector. Figures 4.2 through 4.4 then present the basic results that we discuss in this and the following section. Figure 4.2 shows the estimated gross effect of prices on employment across a range of energy intensities—the estimated function *f* for

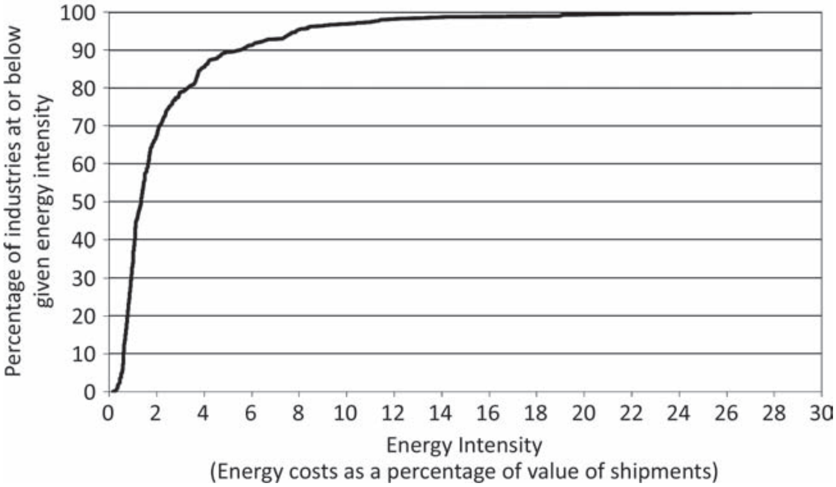

Figure 4.1. Distribution of More than 400 Industry Classifications by Energy Intensity.

Note: Constructed by authors from U.S. Census Bureau *Annual Survey of Manufactures* (multiple dates).

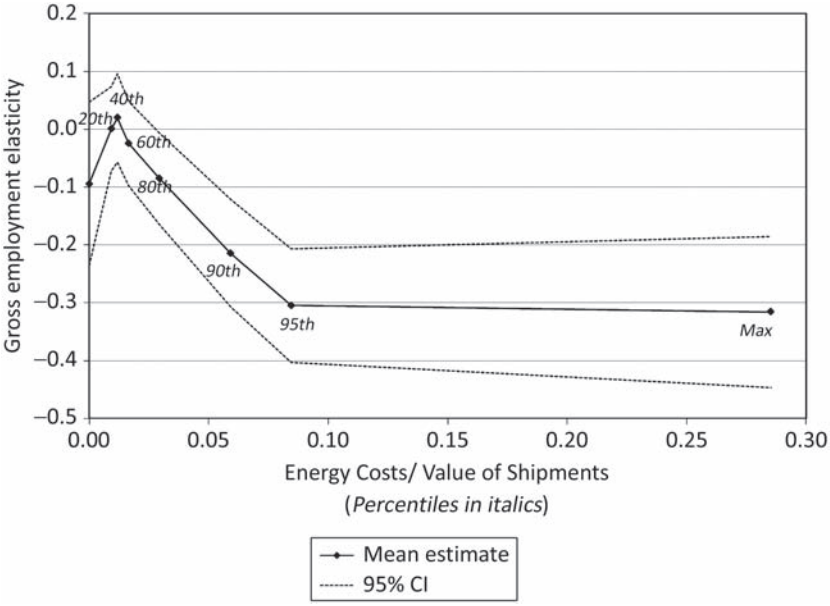

Figure 4.2. Estimated Gross Employment Elasticity.
Note: See Aldy and Pizer (2009). CI = confidence interval.

employment. In particular, we can see that there is no statistically significant effect on employment for the roughly 80 percent industries in our sample with the lowest energy intensities (below 3–4 percent). Above that level, we see employment facing a −0.2 to −0.3 elasticity with respect to electricity prices. As electricity prices rise 5 percent, employment declines 1–1.5 percent.

As noted at the outset, however, this is a gross effect on employment. Some of that impact arises from declining consumption of energy-intensive goods. Some also arises from a shift in production overseas, even as consumption remains unchanged. To estimate the net competitiveness effect on employment, we estimate the effect of prices on consumption and production and then take the ratio of the net import (production – consumption) effects to production effects. That ratio—the share of production effects that can be attributed to competitiveness (net imports)—is shown in Figure 4.3. For the roughly 60 percent of industries in our sample with an energy intensity above 1–2 percent, the estimate of competitiveness as a share of output effects ranges between 20–40 percent. Industries with very small energy intensities have large shares, in some cases exceeding 100 percent, although it is impor-

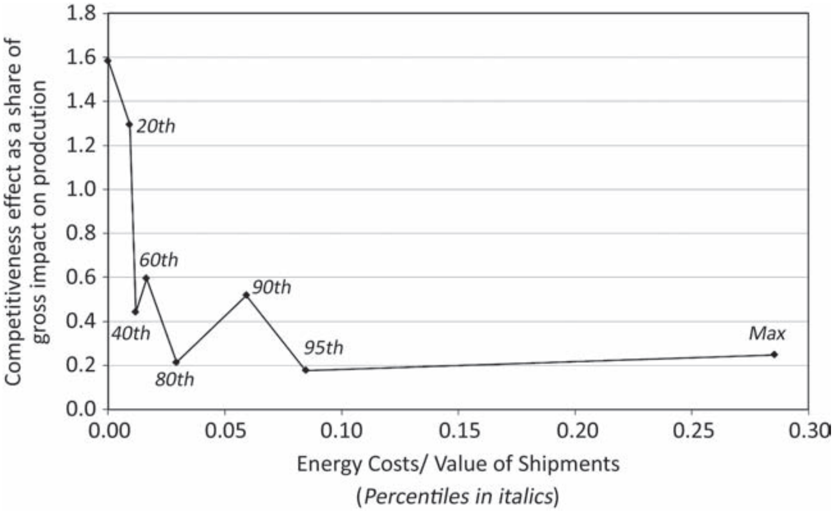

Figure 4.3. Ratio of Change in Net Imports to Change in Total Production for a Change in Electricity Prices.

Note: Constructed by authors based on our statistical analysis and the change in electricity prices predicted under a carbon pricing policy in U.S. Energy Information Administration (2008).

tant to note that neither the production nor the consumption elasticities used to construct this ratio are statistically different from zero in this part of the energy intensity distribution.

We combine Figures 4.2 and 4.3 into an estimate of the net competitiveness effect on employment in Figure 4.4. While the 80 percent of our sample with the lowest energy intensities should have an insignificant effect (from Figure 4.2), the elasticity for the upper 20 percent (above 3–4 percent) varies between −0.05 and −0.1. That is, a 5 percent rise in electricity prices would be expected to lower employment by 0.25–0.5 percent owing to increased imports from jurisdictions not facing similar price increases. This is what we define as the competitiveness effect.

Simulation of an Environmental Regulation: Carbon Pricing

After conducting the statistical analysis described in the preceding section, we use the estimated relationships between electricity prices and our industry impact–competitiveness measures—which vary with energy

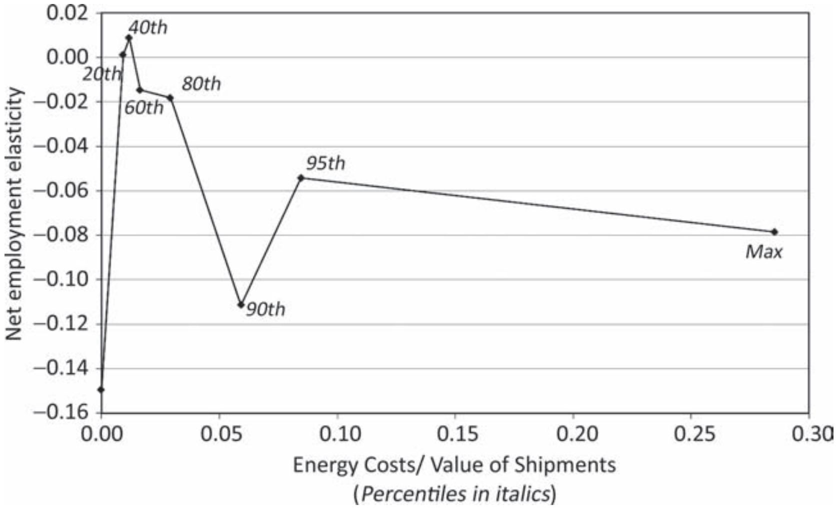

Figure 4.4. Net Employment Elasticity (Product of Estimates in Figures 4.2 and 4.3).

intensity—to simulate the effects of a carbon pricing policy. We assume that the carbon pricing program yields a \$15 per ton CO_2 price in the first year of the program's operation. Although we focus in this simulation on a carbon price—that is, a carbon tax or a cap-and-trade program—it is important to recognize that this analysis could also be applied in a straightforward manner to power-sector carbon dioxide performance standards as well as power-sector renewable portfolio and clean energy standards.

Recent modeling work by the U.S. Energy Information Administration (2008) indicates that a \$15 per ton CO_2 price would increase the cost of electricity in the industrial sector by about 8 percent. This CO_2 price—as an increase in electricity prices—represents approximately a one standard deviation increase in electricity prices given the historic price variation we observe. It would strain the credibility of our approach to use an effective price change that exceeded the values used to estimate the model parameters. Extrapolating impacts for higher CO_2 prices is beyond the scope of this analysis as it would reflect an out-of-sample prediction.[3] This carbon price is similar to allowance prices expected at the start of cap-and-trade programs proposed in recent legislation, including EPA's (2009) estimate of a \$13 per ton CO_2 price under the Waxman-Markey Bill (2009), EPA's (2010) estimate of a \$17 per ton CO_2 price under the American Power Act (2010) (that is, draft legislation from Senators Kerry and Lieberman), as well as the first-year carbon tax of \$15 per ton CO_2 in a 2009 Republican-sponsored carbon tax bill (Raise Wages, Cut Carbon Act of 2009). On the basis of these estimated model parameters, this electricity price increase then drives the competitiveness and employment impacts in our simulation.

Table 4.2 shows the impacts of a \$15 per ton CO_2 price on employment for all manufacturing and for specific sectors of the most energy-intensive industries. Focusing on the first column, the manufacturing average change in gross employment at \$15 per ton CO_2 is −0.2 percent. The energy-intensive industries of iron and steel, aluminum, pulp and paper, cement, glass, and industrial chemicals would experience employment declines of −0.4 to −2.3 percent. Below the reported percentage changes in employment are the estimated changes in the level of employment by industry, which assumes that the employment level in a no-policy counterfactual is on par with 2010 employment data for these industries. The total gross employment change in the energy-intensive industries is a loss of about 10,000 jobs. These estimates reflect the product of the 7.4 percent increase in electricity prices (resulting from the \$15 per ton CO2 price) and the elasticity appropriate for a given industry based on its energy intensity (see Figure 4.2). Each reported industry is an average of the constituent 6-digit NAICS industry esti-

Table 4.2. Predicted Impacts of a \$15 per ton CO_2 Price on Various Manufacturing Sectors, Percentages, and Number of Workers

Industry	*Gross Employment*	*Net Imports / Production*	*Net Employment (Competitiveness)*
Industrial chemicals	−1.6%	0.34	−0.5%
	−5,500		−1,900
Paper	−2.0%	0.28	−0.6%
	−2,200		−600
Iron and steel	−1.1%	0.35	−0.4%
	−2,000		−700
Aluminum	−1.0%	0.32	−0.3%
	−700		−200
Cement	−0.4%	0.49	−0.2%
	−700		−300
Bulk glass	−2.3%	0.18	−0.4%
	−200		−40
Manufacturing average	−0.2%	0.54	−0.1%

Note: Constructed based on our statistical analysis and the change in electricity prices predicted under a carbon pricing policy in U.S. Energy Information Administration (2008). Impacts are based on 2001 industry energy intensity, weighted by 2010 employment reported in the Quarterly Census of Employment and Wages among constituent six-digit NAICS industries based on a crosswalk from four-digit SIC industries listed in appendix 4 of Aldy and Pizer (2009). Number of worker estimates rounded to nearest hundred.

mates weighted by their 2010 employment; the manufacturing average is an average across all 400-plus industries.

We can convert to an estimate of the net competitiveness effect by multiplying the gross effect in column one by the estimate of the competitiveness share of the total production effect from Figure 4.3. Column two in Table 4.2 presents the share of the decline of production as a result of an increase in net imports, which varies by the energy intensity of the industry (see Figure 4.3), while column three reports the product of columns one and two. As expected, the net effects are uniformly smaller. All of the industry-level effects are under 1 percent, and the average for manufacturing as a whole is under 0.1 percent. It is worth noting that some more narrowly defined industries would experience impacts outside this range. The total net employment effect is about 4,000 lost jobs.

These results suggest that consumers of energy-intensive goods do not respond to higher energy prices by consuming a lot more imports. Instead, they economize on their use of these higher-priced manufactured goods, perhaps by using less of the good in the manufacture of their finished products or by substituting with other, less energy-intensive materials. Consumers appear to pursue only partial substitution with imports, suggesting that the imported versions of domestically produced goods may be imperfect substitutes. Other determinants of trade flows—such as transport costs, tariffs, and so forth—may limit the substitution possibilities.

Conclusion

To illustrate the potential impacts of power-sector regulations on manufacturing-sector employment and competitiveness, we have estimated the historical relationship between electricity prices and employment and competitiveness (measured as the share of the output effect attributable to increased net imports). On the basis of our empirical model drawing from more than 400 manufacturing industries, we have simulated the impacts of a power-sector carbon pricing policy. We found estimated gross employment impacts on the order of 0.2 percent for the entire manufacturing sector and on the order of 1 to 2 percent for energy-intensive manufacturing as a result of a $15 per ton CO_2 price in the power sector. The manufacturing-sector competitiveness impacts are less than 0.1 percent for the sector on average and under 1 percent for energy-intensive industries at $15 per ton CO_2.

These carbon pricing impacts also provide a sense of the magnitude of the manufacturing employment impacts of CSAPR, as noted in the introduction. Because U.S. EPA (2011) estimates electricity rate impacts of about 2.2 percent, or approximately 30 percent of the price increase under the \$15 per ton CO_2 scenario, we would estimate a reduction in energy-intensive manufacturing employment of less than one-half of 1 percent, and competitiveness impacts on the order of 0.1 to 0.2 percent.

Given the annual volatility in the economic characteristics of the manufacturing sector, especially energy-intensive manufacturing, the impacts for carbon pricing and CSAPR are likely to be swamped by other drivers in these industries. For example, the less than 1 percent competitiveness impacts resulting from a \$15 per ton carbon pricing policy for energy-intensive manufacturing industries are swamped by the average percentage change in production that ranges from about 6 to 9 percent annually for these industries (Aldy and Pizer 2009).

There are a variety of limitations to these estimates. First, they cannot credibly simulate the impacts of electricity price increases resulting from power-sector regulations much in excess of about 8 percent. Historical experience simply does not tell us what might happen when prices go higher—because we have not seen an isolated, equivalent change in energy prices in available data.[4] Second, our estimates represent near-term impacts over one year to a few years. Unfortunately, volatility in energy prices and the confounding nature of other events make it difficult to estimate long-term impacts. Arguably with more time to adjust, U.S. industry could fare better (if it can reduce energy usage) or worse (if it has more time to move operations). Third, even with our disaggregated data and flexible model, we still cannot flexibly capture all of the features relevant for every industry in every international trading situation. The effects for some firms and sectors could be different than what we have estimated. Fourth, in using historical data, we are necessarily assuming that the past is a useful guide to future behavior. To the extent that there have been or will be substantial institutional changes, this assumption is flawed. Finally, our analysis has focused on the historic influence on net imports arising from domestic energy price increases as a measure of the difference between U.S.-only versus global action. To the extent net imports change significantly even with global regulatory action, our estimates will not capture these effects.

The policy debate on employment and competitiveness impacts of environmental regulations could benefit from additional research. Given the spatial concentration of some industries as well as the heterogeneity in electricity prices and electricity price impacts resulting from environmental regulations, further work focused on regional impacts could enlighten the policy debate. In addition, alternative statistical identification strategies—such as through instrumental variables and regression discontinuity—could enhance the robustness of the findings reported here. Finally, work focused on other developed countries—such as the

European Union in the context of carbon taxes and cap-and-trade—could illuminate the discussion about the employment and competitiveness impacts of climate change policies.

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Notes

1. Note that the U.S. Court of Appeals vacated this rule and remanded it to the EPA on August 21, 2012 (*EME Homer City Generation v. EPA* 2012).

2. We have also undertaken analyses over the 1974–2001 period. We have excluded the 1974–1985 period because it was the era of high energy prices and dramatic restructuring throughout the manufacturing sector. Our primary analysis concludes with 1994 because of data limitations on net imports. It is not possible to create industry-specific series for net imports after 1994. We extend our employment analyses through 2001 in sensitivity analyses. We find that our results are robust to the choice of time period. See Aldy and Pizer (2009) for more details.

3. We do not know if these relationships are linear over a small or large range of carbon prices, and if the relationship becomes nonlinear, theory cannot clarify whether the relationship would become convex or concave.

4. It is important to note that our analysis identifies the effect of electricity prices on employment and competitiveness measures after controlling for economy-wide factors (through year fixed effects) and time-invariant industry-specific factors (through industry fixed effects). It is the residual variation after accounting for time-varying economy-wide factors and time-invariant industry factors that drives our results.

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