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for Resource Owners  
to Form Lobbies  
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# **An analysis of incentives for resource owners to form lobbies**

by

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## **Abstract**

The competition among interest groups' lobbying activities has been widely studied for its great influence on politicians. But little attention has been given to the incentives of individual economic agents to form lobbies. The paper builds a comprehensive theoretical framework based on a general equilibrium model to analyze the incentives of two types of resource owners to form lobbies when the government is tightening environmental control. Under the assumption that the capital intensive industry is more polluted than the labor intensive industry, the model shows that capital owners have an incentive to oppose to the higher environmental standard while laborers have an incentive to support it. The paper also empirically assesses the model's assumption by using production input (capital stock and labor), output, and GHG emission data from U.S industrial sectors. The regression result supports a strong positive relationship between the capital-labor ratio and the pollution-output ratio. Therefore, the theoretical analysis is relevant to the actual economy.

Keywords: lobby, incentive, general equilibrium model, environmental policy

JEL Classification: D10, H41

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# 1 Introduction

In western democratic society, government is viewed as a set of institutions created by individuals for the benefit of people. The function of the government can be viewed as a means to better achieve individuals' goals rather than serve a specific group or person. Based on this view, public policy should reflect the preference of the majority. The same argument applies to environmental policy because substantial government intervention is required for environmental protection where the market mechanism is unable to provide an efficient solution. However, there are cases where government intervention in environmental issues neglects the good of the majority, and this creates many social controversies. Studies show that environmental policy can be influenced by the interest groups whose preference are very different from the majority's choice. Svendsen, Daugbjerg, Hjollund and Branth(12) in their findings on OECD  $CO_2$  taxation found that households pay a tax rate which is six times higher than that paid by the industry because industry lobbies harder against green taxation.

The benefits and costs associated with environmental policy may motivate people with common interest to coalesce for political action. Olson(10)'s classic analysis of economic incentives for collective action suggests that rational, self-interested economic agents have an incentive to form a political action group if net private benefits are expected to be positive. Therefore, when firms in an industry foresee that an environmental policy will increase production cost, they will form an interest group to lobby against that policy. Similarly, individuals who place high value on the environmental quality are motivated to actively participate in political processes that they expect to determine environmental outcomes.

Lobbying may have a great influence on the environmental policy. Based on the model of trade policy determination by Grossman and Helpman(6), a strand of literature on corruption, lobby and environmental policy follows the same winner-loser idea to explain the behaviors of government, polluters and environmentalists. Lopez and Mitra(9) present a game-theoretic model in which income transfer from a producer lobby to the government has a negative monotonic relationship to environmental policy stringency. Fredriksson(4) develops a model in which both environmentalists and producers make political contributions to influence environmental policy. Damania and Fredriksson(2) show that more collusive industries with higher collusive profits have a greater incentive to form and contribute to lobbies. They also find that more polluting industries have a greater incentive to form and contribute to a lobby group.

The current literature focuses on the gain and loss of economic agents faced with environmental regulation but provides only limited explanations for the lobbying conducted by agents who are neither nature lovers nor polluters. A well-known example is the 1999 coalition between North American labor unions and environmental organizations(8). The coalition's goal was to reform the governance of international trade on environmental standards. However, the incentive of labor unions to join forces with environmental groups on a non-labor related issue is intriguing because the direct economic interest cannot provide justification for such a coalition.

In this chapter we examine clues about how to rationalize the engagement of seemingly unrelated interest groups in environmental policy lobbying. Fredriksson and Gaston(5) find that a union's attitude toward an environmental policy may be determined by the policy's anticipated effect on unemployment. Their study shows that with a risk of unemployment, unions lobby with employers to resist stricter environmental policies. When employment is secure, unions may support policies that reduce employment opportunities for nonunion workers. Therefore, "Environmentalism" can arise without explicit environmental concerns among workers. Damania and Fredriksson(3)'s research results highlight the impact of product market competition on the ability to lobby for less stringent environmental policies. Their conclusion is that if trade liberalization causes industry collective action to become harder to sustain, the stringency of the environmental policy is likely to rise.

Lacking a comprehensive theoretical framework, most of the current literature only discusses labor unions' incentives or firms' abilities to lobby for (or against) an environmental policy. To establish a broader structure to explain economic agents' incentives to form lobbies, our study aims first to create a framework based on fundamental economic theory and then to empirically assess the underlying assumptions of the framework. By investigating the potential impact of environmental policy on the resource owners, the theoretical analysis will provide insight regarding the owners' incentives to lobby. Special attention is drawn to the interests of two important economic agents, labor and capital owners, to shed light on their support for or opposition toward a more stringent environmental policy.

## **2 The model**

A stringent environmental policy achieves its goal through various policy options. These policy options usually require producers to increase labor or capital (or both) to reduce pollution. The technology standard, for example, is a type of regulation that requires firms to use a particular technology to reduce pollution. To comply with such a standard the firm has to spend more on capital to procure the specific technology that is required by law. An emission quota is another policy tool which receives much attention in pollution control. Unlike a technology standard, its flexibility allows firms to choose among various compliance options, which creates incentives for producers to increase abatement investment so that the conversion rate between quota and output will be high. Many countries use a Pigouvian tax in pollution control. The pollution unit tax can speed up production substitution. Equipment and machinery with lower emission will replace the old ones quickly. Jorgenson and Wilcoxon(7) find that pollution abatement has emerged as a major claimant on the resources of the U.S. economy as repercussions of environmental regulations. Requate and Unold(11) investigate use of environmental policy to encourage firms to adopt advanced abatement technology. They find taxes provide stronger incentives than permits, auctioned and free permits offer identical incentives, and standards may give stronger incentives than permits. The increase in abatement provides strong evidence suggesting that once a new environmental instrument is adopted, the production structure and cost for producers will change.

The economy shifts toward a new equilibrium when a stringent environmental policy sets new constraints on firms' production functions. Consequently, the input proportions will be changed. Assuming the polluting industry is capital intensive, this study applies Heckscher-Ohlin theory to find out if a more stringent policy leads the industry to become more or less capital intensive. If the policy outcome induces movement toward a greater capital-labor ratio, the price of capital in the input market will rise. The same increase will occur to the real wage if the industry becomes more labor intensive. The change in the relative factor prices may prompt resource owners to support or oppose a more stringent policy.

The paper has two parts. In the first part, we build a theoretical model to explain the effects a more stringent standard has on factor markets. The theoretical model will contain a closed economy model and an open economy model. In the second part, we analyze a data set to assess whether the polluted industry is actually capital intensive, as assumed in the theoretical model.

## 2.1 Closed economy

Consider a two-sector, closed economy in which one sector produces pollution in the production process but the other does not. The sectors employ two factors, capital (K) and labor (L), to produce two goods. The polluted industry is capital intensive and the clean industry is labor intensive. In equilibrium, both factors are fully employed. The two-sector closed economy with full employment is depicted in figure 1.

In figure 1,  $X_C$  and  $X_D$  are the isoquants for the clean and polluted industry.  $\bar{L}$  and  $\bar{K}$  are the economy's endowment of labor and capital. E is the equilibrium. The absolute value of the slope of line  $F_0F_0$  is the relative price of capital, that is, the price of capital in terms of labor. We can use the following equations to describe the economy.

$$L_C X_C + L_D X_D = L^D = \bar{L} \quad (1)$$

$$K_C X_C + K_D X_D = K^D = \bar{K} \quad (2)$$

$L_C$  is amount of labor used to produce one unit of output for the clean industry at equilibrium.

$L_D$  is the amount of labor used to produce one unit of output for the dirty industry in equilibrium.

$K_C$  is the amount of capital used to produce one unit of output for the clean industry in equilibrium.

$K_D$  is the amount of capital used to produce one unit of output for the dirty industry in equilibrium.

$X_C$  is the output of the clean industry in equilibrium

$X_D$  is the output of the dirty industry in equilibrium

$L^D$  is the total labor demand.

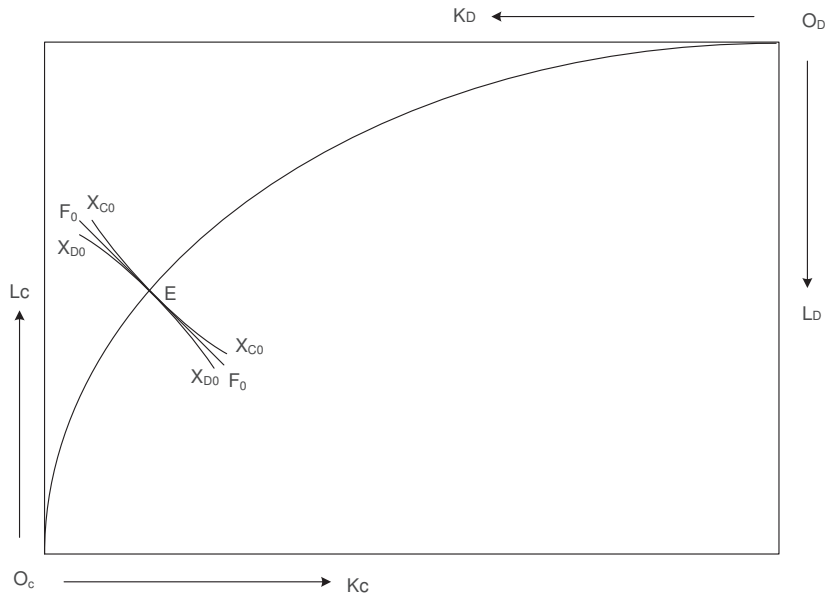


Figure 1: Edgeworth box for a two-sector closed economy

$K^D$  is the total capital demand.

$\bar{L}$  is the total labor supply.

$\bar{K}$  is the total capital supply.

Now assume that government implements a new environmental policy which imposes a pollution tax on the output of the dirty industry. The tax shifts up the supply curve so the market equilibrium price increases and market equilibrium quantity decreases. Therefore, the polluted industry starts to contract.<sup>1</sup> When the polluted industry starts to contract, initially, the wage-rent ratio is unchanged in the factor market. However, the clean industry has to expand in order to reach full employment. But the clean industry is labor intensive. The initial factor price ratio will be inconsistent with the factor market equilibrium, since it will involve an excess demand for labor and/or excess supply for capital. This occurs because at initial factor prices, the expanding industry tries to attract more labor per unit of capital than the contracting industry releases. This leads to a change in relative factor prices. The mathematical explanation for the disequilibrium is provided as follows:

<sup>1</sup>Instead of assuming a tax on the dirty industry, we could assume that the government imposes on the dirty industry a pollution abatement requirement that raises capital and labor input requirements per unit of output proportionately, causing unit costs to rise. Provided that demand elasticity is greater than 1 in absolute value, the industry's revenue will fall. As its revenue falls, its demand for capital and labor inputs will decrease.

First we assume one factor input unchanged and allow the other to change with the change in outputs for the two industries. So starting with  $K$  fixed, we have

$$K_C dX_C + K_D dX_D = 0 \quad (3)$$

$$K_C dX_C = -K_D dX_D \quad (4)$$

$$dX_D = -\frac{K_C}{K_D} dX_C \quad (5)$$

Now we allow  $L$  change to with the output.

$$L_C dX_C + L_D dX_D = dL \quad (6)$$

$$L_C dX_C + L_D \left( \frac{-K_C}{K_D} \right) dX_C = dL \quad (7)$$

$$dX_C \frac{L_C K_D - K_C L_D}{K_D} = dL \quad (8)$$

Because polluted industry is capital intensive and clean industry is labor intensive, we have the following relationship :

$$\frac{K_C}{L_C} < \frac{K_D}{L_D} \quad (9)$$

$$K_C L_D < K_D L_C \quad (10)$$

Using the relationship in Equation 10, we find the term  $L_C K_D - K_C L_D$  is positive. So the numerator in Equation 8 is positive. Equation 8 tells that when  $X_C$  increases,  $L$  must move in the same direction.

Next, we assume  $L$  is unchanged and solve for the relationship between  $dX_C$  and  $dK$ . The same process applies and we find,

$$dX_C \frac{K_C L_D - K_D L_C}{L_D} = dK \quad (11)$$

Since the term  $K_C L_D - K_D L_C$  is negative, when  $X_C$  increases,  $K$  must decrease.

Equations 8 and 11 mean that, if both factor markets initially clear, an expansion of the clean

industry and contraction of the dirty industry will create, at initial factor prices, excess demand for labor and/or excess supply of capital. When there will be excess demand for labor, the wage must increase. Also, when there is excess supply of capital, the rent must decrease. The adjustment process will happen until the market reaches equilibrium again. This can be proved by the following:

Assume that the production function for the polluted industry, written as

$$X_D = F_D(K_D, L_D) \quad (12)$$

is linear homogeneous, so that

$$X_D = L_D F_D\left(\frac{K_D}{L_D}, 1\right). \quad (13)$$

Defining  $k_D := \frac{K_D}{L_D}$  and  $f_D(k_D) := F_D\left(\frac{K_D}{L_D}, 1\right)$ , we can write,

$$X_D = L_D f_D(k_D) \quad (14)$$

Assuming that  $\frac{\partial F_D}{\partial K_D} > 0$  and  $\frac{\partial^2 F_D}{\partial K_D^2} < 0$ , we have  $f'_D > 0$  and  $f''_D < 0$ . The marginal product of labor (*MPL*) and marginal product of capital (*MPK*) are derived as follows:

$$MPL_D = L_D f'_D(k_D) \left(-\frac{K_D}{L_D^2}\right) + f_D(k_D) = f_D(k_D) - f'_D(k_D) k_D \quad (15)$$

$$MPK_D = L_D f'_D(k_D) \frac{1}{L_D} = f'_D(k_D) \quad (16)$$

Equation 15 and Equation 16 show that the two marginal product only depend on  $k_D$ . Furthermore,

$$\frac{dMPL_D}{dk_D} = -k_D f''(k_D) > 0 \quad (17)$$

and

$$\frac{dMPK_D}{dk_D} = f''_D(k_D) < 0 \quad (18)$$

The real wage rates for labor and capital are determined by the marginal product of labor and the marginal product of capital. That is:

$$MPK_D = f'_D(k_D) = \frac{r}{P_D} \quad (19)$$



$$MPL_D = f_D(k_D) - f'_D(k_D)k_D = \frac{w}{P_D} \quad (20)$$

Analogous equations relate to the clean industry:

$$MPK_C = f'_C(k_C) = \frac{r}{P_C} \quad (21)$$

$$MPL_C = f_C(k_C) - f'_C(k_C)k_C = \frac{w}{P_C} \quad (22)$$

$$\frac{dMPL_C}{dk_C} = -k_C f''_C(k_C) > 0 \quad (23)$$

$$\frac{dMPK_C}{dk_C} = f''_C(k_C) < 0 \quad (24)$$

When the new policy shifts the equilibrium from  $E$  to  $E'$  (see figure 2),  $k_D$  and  $k_C$  both rise. Hence,  $MPK_D$  and  $MPK_C$  fall and  $MPL_D$  and  $MPL_C$  rise. Therefore, the real rent will decrease and the real wage will increase.

Figure 2 illustrates the adjustment process toward the new equilibrium.  $X_{C0}$  and  $X_{D0}$  are the initial isoquants for clean and polluted industries. After the government implements the new standard, the polluted industry contracts to  $X_{D1}$ . Such contraction leads to excess labor and capital supply. The clean industry starts to expand. A new equilibrium emerges at  $E'$  where the demands for labor and capital are equal to supply. The absolute value of the slope of line  $F_1F_1$  is the new relative price of capital in terms of labor. According to our derivation, line  $F_1F_1$  should be flatter than line  $F_0F_0$ .

## 2.2 Open economy

The open economy model also has two industries, one is dirty and the other is clean. Both industries are assumed to be perfectly competitive. Again, the dirty industry is capital intensive and the clean industry is labor intensive. This model is represented by a Lerner Diagram (Figure 3), in which  $X_C$  and  $X_D$  are the unit value isoquants for clean and polluted industries.<sup>2</sup> The two industries' unit value isoquants are tangent to the same unit value isocost line. The absolute value of the slope of the unit value isocost line is the ratio of the rental cost of capital to the wage rate. Assume the endowment of labor and capital,  $E$ , falls inside the cone so that factor markets clear for some combination of positive output levels for the two industries.  $P_C$  and  $P_D$  are the commodity prices

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<sup>2</sup>A unit value isoquant consists of input bundles that generate the amount of output that has a market value of 1 dollar.

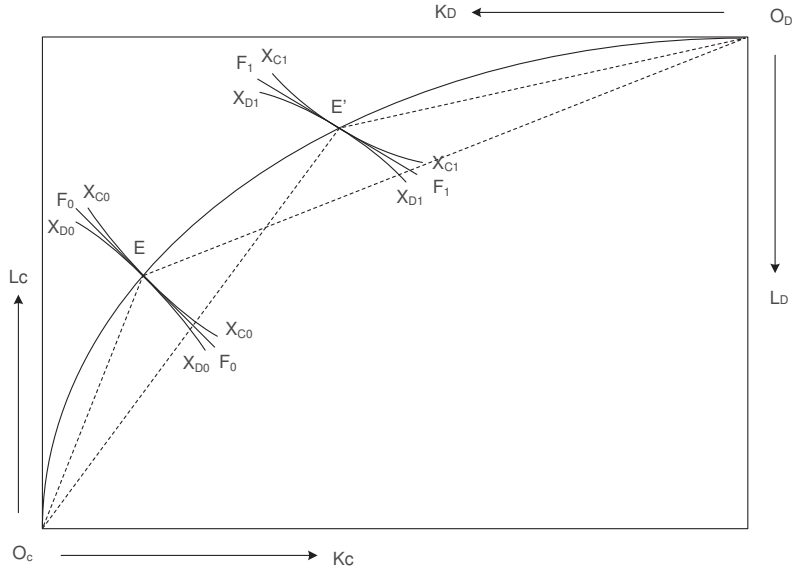


Figure 2: Edgeworth box for the new equilibrium

for the clean and polluted industry. Because it is an open economy,  $P_C$  and  $P_D$  are exogenous to the model. To avoid a profit or loss that would lead to entry or exit, this cost-minimizing bundle of factors must also be worth exactly one dollar, just like the output it produces. Therefore, the isocost line drawn through the tangent point must represent one dollar's worth of factors. Hence its vertical intercept is one dollar worth of labor, or one over the wage  $w$ , while its horizontal intercept is one dollar worth of capital, one over the rental  $r$ , as labeled.

Before the environmental policy is implemented, the dirty industry and the clean industry isoquants are tangent with the unit isocost line at  $(L_D, K_D)$  and  $(L_C, K_C)$  respectively. A set of equations describing the relationships among  $K$ ,  $L$ ,  $r$  and  $w$  are as follows:

$$L_C w + K_C r = 1 \quad (25)$$

$$L_D w + K_D r = 1 \quad (26)$$

$L_C$  is amount of labor per dollar of output in the clean industry.

$K_C$  is amount of capital per dollar of output in the clean industry.

$L_D$  is amount of labor per dollar of output in the dirty industry.

$K_D$  is amount of capital per dollar of output in the dirty industry.

$w$  and  $r$  are the factor prices.

The two sectors are price takers in the world market. Therefore, prices are treated as given.

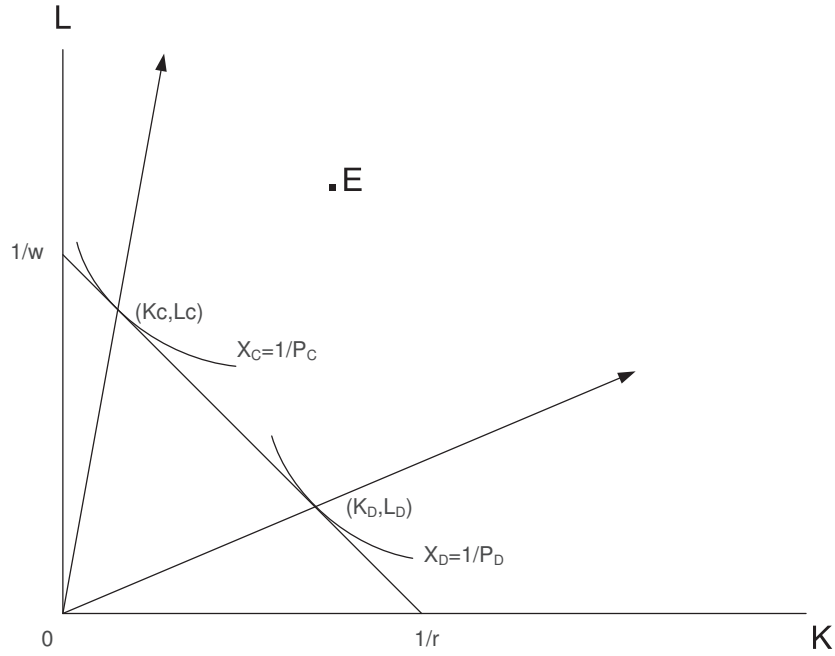


Figure 3: Lerner Diagram for two sector open economy

The isoquants, as their tangencies with the isocost line have the same slope, namely:

$$\frac{dL_C}{dK_C} = \frac{dL_D}{dK_D} = -\frac{r}{w} \quad (27)$$

Now the new environmental policy requires the polluted industry to use more labor and capital per dollar of output. It shifts out the unit value isoquant for the polluted industry. Figure 4 describes such a change. A new isocost line will be established tangent to the new isoquant of the polluted industry and the old isoquant of the clean industry. At the new tangency, the amounts of labor and capital used are  $L'_D$ ,  $K'_D$ ,  $L'_C$ , and  $K'_C$ .

At cost minimization, the slope of the two tangency points is :

$$\frac{dL'_D}{dK'_D} = \frac{dL'_C}{dK'_C} = -\frac{r'}{w'} \quad (28)$$

And

$$\left| \frac{dL}{dK} \right| = \frac{dX}{dK} \frac{dL}{dX} = \frac{MPK}{MPL} \quad (29)$$

Equation 29 holds true at equilibrium.

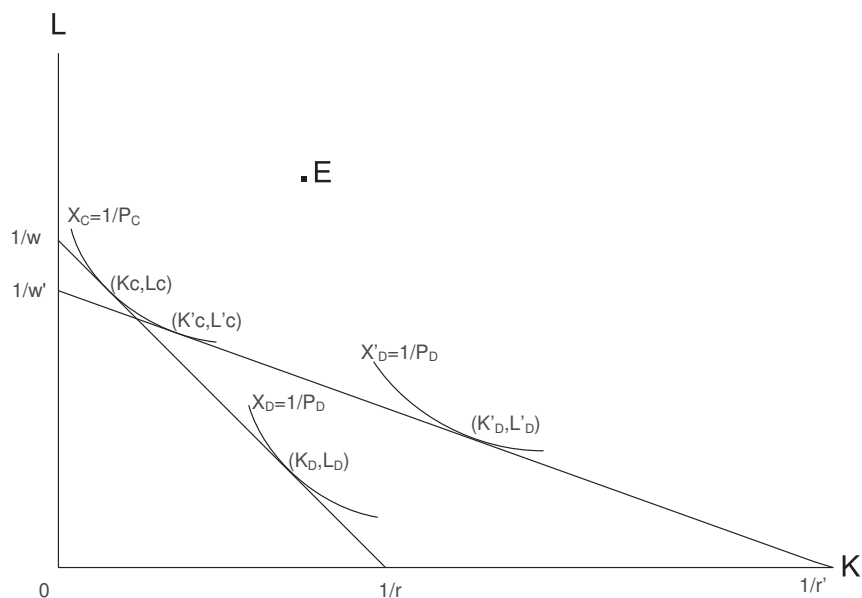


Figure 4: Lerner Diagram for two sector open economy

Therefore,

$$\left| \frac{dL}{dK} \right| = \frac{MPK}{MPL} = \frac{r}{w} \quad (30)$$

At the new equilibrium,  $\frac{MPK_D}{MPL_D} = \frac{MPK_C}{MPL_C} = -\frac{r}{w}$ . From the Lerner Diagram, we can see that the new tangency on the clean industry's isoquant is to the right of the old tangency. Therefore, at the new tangency, the capital labor ratio is greater than the old tangency. It means  $MPK_C$  will become lower and  $MPL_C$  will become greater. Because  $\frac{MPK_D}{MPL_D} = \frac{MPK_C}{MPL_C} = -\frac{r}{w}$  at equilibrium, it means that the rent will be reduced and the wage rate will be higher compared with the initial equilibrium.

The implication for the model (in which the dirty industry is capital intensive) is that capital owners have the tendency to oppose a stringent environmental policy and workers are more sympathetic toward environmentalists. When the real wage can be raised by a new environmental policy, workers have incentives to ally themselves with environmental groups lobbying for a stricter standard. At the same time, the capital owners would feel reluctant to support a stringent policy for it will reduce their capital return.

### 3 Empirical Study

The theoretical models developed above are based on the assumption that the polluted industry is capital intensive. The assumption captures the general impression that heavily polluted industries

seem to involve high levels of capital in production. The petrochemical industry and oil drilling industry are examples. However, to strengthen our theoretical work, it is important to use empirical data to verify this assumption. The aim of this section is to find out if there is a positive correlation between capital labor ratio and pollution output ratio.

To collect data for this purpose, we choose the United States as study area. The US has complete time-series production input and output data. We use total hours of labor input and productive capital stock to estimate the labor-capital ratio at the industry level. When estimating capital input as the production factor, the common practice is to include equipment and structures. Inventory and land are not included. Both capital and labor data come from the Bureau of Labor Statistics (BLS). The capital input data includes the following sectors: private business, private nonfarm business, manufacturing, farm sector and nonfarm nonmanufacturing. Productive capital stocks are derived from the National Income and Product Accounts(NIPA) investment which uses the perpetual inventory method and assuming that capital services decline as a function of age to obtain the estimates of capital stock value. BLS provides industry level capital input data and labor input data based on the North American Industry Classification System (NAICS). The NAICS code is the standard used by Federal agencies in classifying business establishments for the purpose of collecting, analyzing, and publishing statistical data related to the U.S. industries.

We calculate industry level pollution intensity as pollution per unit of value added.<sup>3</sup> The data on value added by industries (as delineated in NAICS) are provided by the Bureau of Economic Analysis (BEA).

Greenhouse gases (GHG) emission is the proxy for pollution in our study. Scientific evidence has shown that increasing concentrations of greenhouse gases in the atmosphere causes global warming, which has potentially harmful consequences for the environment and human health. From the beginning of the industrial era, human activities have rapidly added greenhouse gases to the atmosphere, mainly through the burning of fossil fuels. GHG is among the most common pollutants, generated in both the commercial and residential sectors. Carbon dioxide, methane, nitrous oxide and three groups of fluorinated gases (sulfur hexafluoride, Hydrofluorocarbons(HFCs), and perfluorocarbon(PFCs)) are the major greenhouse gases. They are also the subject of the Kyoto Protocol, which came into force in 2005.

The US Environmental Protection Agency (EPA) ranks the industrial sectors as the major greenhouse gas contributing end-user sectors. The most detailed source of information on U.S. GHG emissions is the Inventory of U.S. Greenhouse Gas Emissions and Sinks, issued by the EPA Office of Atmospheric Programs. This source provides detailed emissions data, broken down by industrial process. The inventory provides GHG breakdown by production process. Only in a

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<sup>3</sup>Valued-added output is an appropriate measure for industry output because it excludes the value of intermediate inputs. Some industries have a high value of intermediate inputs, using the value of total commodity output in this case will exaggerate the value of output the industry creates. By choosing value-added as the measure of output we can avoid overestimating the actual value of the output.

few cases (cement manufacturing, for example) does the breakdown by process correspond to the breakdown by NAICS code sector. We find that it is impossible to derive sector-specific information directly from the process data provided in the Inventory. However, in our study, a sector-specific breakdown is desirable. One way to derive reliable industrial GHG estimates is to convert the current sectoral energy consumption data to carbon dioxide equivalence. This is the approach that is recommended by the National Center for Manufacturing Sciences. According to EPA, energy consumption is the major source of industrial GHG emission. The approach adopted for our study is based on the fact that, for many sectors, the total contribution of the sector processes to overall GHG emissions is dominated by the carbon dioxide generated from fossil fuel combustion. Therefore, data from the Energy Information Administration (EIA) of the US Department of Energy Information on energy consumption for specific fossil fuel types, broken down by sector, can be used to convert to sectoral GHG emission. Because the carbon content of each fossil fuel type is known, using an estimated conversion factor one can convert fuel usage figures into GHG emissions for each sector covered by the EIA energy usage information.

EIA has energy consumption data for 21 manufacturing sectors based on 3 digit NAICS code for years 1998, 2002 and 2006. The 21 manufacturing sectors in the EIA dataset are listed in Table 1.

Table 1: Industrial sectors that are listed in the EIA energy consumption dataset

NAICS	Industry	NAICS	Industry
311	Food	326	Plastics and Rubber Products
312	Beverage and Tobacco Products	327	Nonmetallic Mineral Products
313	Textile Mills	331	Primary Metals
314	Textile Product Mills	332	Fabricated Metal Products
315	Apparel	333	Machinery
316	Leather and Allied Products	334	Computer and Electronic Products
321	Wood Products	335	Electrical Equip., Appliances, and Components
322	Paper	336	Transportation Equipment
323	Printing and Related Support	337	Furniture and Related Products
324	Petroleum and Coal Products	339	Miscellaneous
325	Chemicals		

Table 1 clearly shows that major industrial sectors are included in the EIA energy statistics. The data captures most of the emission in manufacturing industry. Cross referencing the industry

sectors in both EIA data and EPA inventory, EIA fossil fuel consumption data based on NAICS codes provide a reasonably close mapping to the selected sectors that are of interest for the GHG concern. For example, sectors such as Agricultural Chemicals, Aluminum, Automobile Assembly, Cement, Chemicals, Computers and Electronics, Iron and Steel, Petroleum Refining, Plastics, Pulp and Paper, Rubber, Semiconductors, Stone, Clay and Glass, Textiles, and Wood products have been the important GHG contributors in the manufacturing industry, according to the inventory(1). All of these sectors are categorized into the NAICS codes that are listed in table 1. Their corresponding 3 digit NAICS code are: 325, 331, 336, 327, 325, 334, 331, 324, 325, 322, 326, 334, 327, 313, and 321.

Total energy consumption for each sector is estimated based on data for energy generated from the following energy sources: net electricity, residual fuel oil, distillate fuel oil, natural gas, liquefied petroleum gases (LPG) and natural gas liquids(NGL), coal, coke and breeze<sup>4</sup>, other, and shipments of energy sources produced on site. The total energy consumption is the sum of all of the listed energy sources, including “other”, minus the shipments of energy sources produced on site. It is the total amount of first use of energy for all (fuel and nonfuel) purposes. Shipments of energy sources produced on site are those shipments produced or transformed on site from the nonfuel use of other energy sources. For example, at an establishment that processes coal to make coke for later use, the entire quantity of coal is counted as first use. Any onsite consumption of coke is not counted as first use because it would duplicate the coal use. If some of the coke is then sold to another establishment, then that second establishment will consider this coke to be a shipment of an offsite-produced energy source. Hence, the second establishment will count this coke as its first use, thereby resulting in double counting. In order to eliminate the double counting, the energy equivalent of the coke shipment must be subtracted from first use.

The Environmental Roadmapping Initiative of the National Center for Manufacturing Sciences provides conversion factors for each EIA’s fuel type. Table 2 shows the GHG conversion factors for the EIA energy sources.

Using the conversion factors, we derive the total GHG emission from EIA sectoral energy consumption data. Then dividing GHG emission by value added, we can obtain data on emission per dollar, which is the dependent variable in our model. Using the capital labor ratio as the regressor, we obtain the regression result shown in Table 3 model 1.

The sign of the coefficient for K/L ratio is positive, which is consistent with our expectation. It means when the capital intensity increases, pollution intensity also increases. Furthermore, the t ratio for capital is large and significant. It supports our assumption that a polluted industry is indeed capital intensive.

Because industry level time series data are used in our data, time-varying factors such as technological progress, weather/temperature, change in regulations, or economic cycle could also affect

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<sup>4</sup>A by-product of coke manufacture; it is the residue from the screening of heat-treated coke. The particle size is less than 10 mm.

Table 2: GHG conversion factors by energy types

Energy source	Conversion factor (Tg CO <sub>2</sub> eq per trillion Btu)	Notes
Net electricity	0.075	Teragram (Tg) is a weight measurement which equals 10 <sup>12</sup> grams. Energy bought and generated, minus energy sold offsite. Factor is a midrange value, since fuel type used for generation is unspecified
Residual fuel oil	0.0788	
Distillate fuel oil	0.0732	Nos. 1, 2, and 4 fuel oils and Nos. 1, 2, and 4 diesel fuels
Natural gas	0.0531	
LPG and NGL	0.0623	Examples include: ethane, ethylene, propane, propylene, normal butane, butylene, ethane-propane mixtures, propane-butane mixtures, and isobutane
Coal	0.0940	
Coke and Breeze	0.0937	
Other	0.075	Includes net steam, and feedstocks. Factor is a midrange value.
Shipments of Energy Sources Produced onSite	0.075	Shipments to other sites of material to be used as fuel. This quantity is subtracted from the others, to avoid double counting. Factor is a midrange value.

GHG emission per dollar. Therefore, we need to extend our model by adding year dummy variables. The regression result for the second model is also in Table 3. Model 2 shows the coefficient of K/L ratio is consistent with the result in the first regression model and its value and t ratio are larger than the result in the first model.

There are two year dummies in model 2, but only the coefficient for year 2006 reaches the level that is necessary for statistical significance. This seems to be encouraging because it shows that the US major manufacturing sectors have decreased GHG intensity in the production process in the recent years. The reduction could be the result of the change in both environmental regulations and the public awareness in response to the concern of global warming. However, complete time series data and further research are required to pin down the underlying factors that contribute to the improvement.



Table 3: Regressions for pollution per dollar of output

Model 1	Constant	K/L ratio	dummy02	dummy06
Coefficient	-0.84 (-2.56)	0.026 (11.36)		
$\bar{R}^2$	0.7072			
Model 2				
Coefficient	-0.14 (-0.311)	0.027 (12.519)	-0.55 (-0.961)	-1.81 (-3.113)
$\bar{R}^2$	0.7471			

t-ratios in parentheses

## 4 Conclusion

When general equilibrium theory is applied to predict the effect of a higher environmental standard on factor prices, the inference is that wages will rise and the rental cost of capital will fall. If workers and capital owners take political positions based on economic self interest, stricter environmental policies will be supported by the former and opposed by the latter. The result of our empirical study shows strong evidence to support the assumption that the capital intensive sectors tend to produce more pollution since the coefficient of capital labor ratio is positive and statistically significant. The result suggests that when an industry becomes more capital intensive, the economy is likely to be dirtier if there is no adequate government intervention. Policy makers should be cautious about the environmental consequence when designating investment policy to increase capital stock in the production process to pursue economic development.

The pollution proxy that is chosen in our study allows us to reveal the specific relationship between GHG emission and the factor input composition. An important implication from our result is that capital owners have an incentive to join forces across sectors to oppose the GHG reduction policy. The imposition of a stringent environmental policy will decrease the capital price relative to product prices and increase wages relative to these product prices. This provides incentives for self-interested capital owners to oppose to a stricter environmental policy and for laborers to support it.

To the extent that firms use their own capital, rather than borrowed capital, firms in capital-intensive industries will have an incentive to join the coalition against GHG reduction policies. In most industrial countries, GHG reduction policy has thus far targeted only the electricity companies. With stricter policies towards climate change, the energy end users will soon find themselves under government regulation for GHG especially the major manufacturing sectors that have high

electricity demand. As a result, there is a great likelihood that the rent seeking, highly capitalized industry will vigorously work together against the GHG abatement policy.

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