IMPACT OF POLLUTION ABATEMENT COSTS ON MANUFACTURING EMPLOYMENT IN THE U.S.

1. INTRODUCTION

Since the Clean Air Act of 1970 and the various amendments thereto through 1990, environmental quality and pollution control have become an increasingly controversial economic and social issue in the U.S. Under this federal program, the EPA (Environmental Protection Agency) requires all states to conform to national standards for air quality and to control the emissions for new sources of pollution (http://www.epa.gov). The Clean Air Act authorizes the EPA to establish “national ambient air quality standards” to significantly limit emissions of major polluting chemicals in the air and to use legal methods to make polluters obey air pollution control policy. All areas in the United States are defined as either “attainment” or “non-attainment” areas, depending on whether the level of the criteria pollutants meets the established health-based standards. The states which comprise non-attainment areas are statutorily required to develop formal plans by which to achieve such standards, and if a state chooses not to form such a plan or does not successfully execute that plan by a specified date set by the EPA, the EPA is allowed to assume administration of the law for the state. However, if the law is still not enforced, then “…members of the public can sue the EPA or state or local governments to get action” (http://www.epa.gov).

The Clean Air Act was last amended in 1990, and these amendments are considered the most far-reaching revisions of the original 1970 law. According to the official website of the EPA, before 1990 all enforcement actions, which included citations of polluters, fines, and even (potentially but unlikely) prison terms, had to be handled through the court system. The 1990 Clean Air Act gave the EPA authority to fine violators without going to court first; this new authority (at least in theory) enables the EPA to accelerate prosecution of those entities violating compliance with the law and reduces court time as well as court costs.
Given that, in thousands of tons emitted annually, air pollution emissions in the U.S. have declined from 13,042 in 1970 to 4,450 in 1998 [U.S. Census Bureau (2001, Table 356)], the Clean Air Act can potentially be regarded as a successful law contributing to the reduction of many pollutants in the air. However, in a general equilibrium sense, any such assessment of the Clean Air Act (and its amendments) requires a cost/benefit analysis involving economic and non-economic costs associated with pollution abatement efforts on the one hand and economic and non-economic benefits associated with the improvement of environmental quality. For example, many economists suggest that there is a trade-off between environmental protection and the manufacturing employment in the U.S. Considering the fact that “…over the last twenty-five years, spending on environmental protection in the United States has grown even faster than has spending on health care,” the impact of environmental protective measures on U.S. manufacturing activity warrants attention (Goodstein, 1995, p. 42). The purpose of this empirical study is to establish whether the impact of pollution abatement costs on manufacturing employment is indeed deleterious. Predicated upon a cross-sectional analysis for 50 states in the year 2000, this study finds strong empirical support for the argument that pollution abatement costs have a negative and statistically significant effect on employment in the U.S. manufacturing sector.

2. Brief Literature Review

There exist a modest number of studies that empirically investigate the potential economic impacts of pollution abatement efforts. Most of these studies have concentrated primarily on investigating firms’ decisions to relocate their production and/or decrease the number of their employees or whether productivity is diminished as a result of more stringent pollution abatement requirements. However, within this literature, there also are a number of interesting perspectives that have been proffered with regard to the adoption of pollution abatement initiatives or the impacts of a cleaner environment.

One perspective raised in the literature is that environmental protection costs – at times estimated to constitute only a modest portion of total business costs – may not be high enough to have a significant effect on a large plant’s activity (Goodstein, 1995, p. 44). On the other hand, in the case of a smaller plant, additional pollution abatement costs may become a decisive point contributing
to the plant’s shutdown decision or decision to introduce employee layoffs (Goodstein, 1995, p.44).

Duffy-Deno (1992, p. 420) introduces the perspective that higher pollution abatement compliance costs may also be regarded as a barrier to entry for new firms, and existing firms may enjoy protection from new entry and less competition because of these costs, thus leading to greater economic profits. Alternatively, Duffy-Deno (1992, p. 420) argues that at least some firms may be inclined to extend the use of their old facilities in order to avoid the costs associated with a new facility “…since environmental regulations frequently consider any new facility within an existing plant as a source…” for pollution, which would contribute to more pollution or offset pollution abatement efforts. This creates the irony that failing to adopt new technology could – in the short – actually be more profitable at the margin than the adoption of more modern technology.

From a different perspective entirely, there is the more macroeconomic idea that geographic regions that successfully adopt pollution abatement initiatives so that they actually experience a cleaner environment can reap a variety of benefits. As Cebula and Payne (2005) have found, areas with safer environments attract migrants and experience greater economic growth and development. To the extent that new firms are attracted to those areas by market-based profit incentives, it is more likely that “cleaner” industry will develop as new plants and other new facilities are constructed in conformity with the Clean Air Act and its amendments as well as other environmentally-friendly considerations. Moreover, there obviously would be profound public health benefits to be reaped from a cleaner environment.

These perspectives aside, it is noted that, given the variety of methods and the diverse terminology used to address economic impacts of pollution abatement initiatives on firms per se or industries per se, it is not surprising that the existing literature provides a variety and diversity of findings. To illustrate, we begin with the study by Conrad and Morrison (1989), which investigates the impact of environmental controls on the productivity growth in three important industrial countries, namely, the U.S., Canada, and Germany. This study seeks to empirically test whether the introduction of stricter environmental regulations is indeed a partial explanation for the productivity growth slowdown observed by many industrialized countries in the early 1970s. The study observes that “...treating
pollution abatement capital incorrectly in productivity computations has biased productivity measures downward...” (Conrad and Morrison, 1989, p. 696), with the actual conclusion being that the effects of pollution abatement efforts on productivity growth is not major.

A more recent study performed by Becker (2005) adopts micro, i.e., establishment-level, data for some 90,000 observations over the time period from 1979 through 1988. His findings imply that pollution abatement expenditures have a significant impact on local manufacturing activity such as plant location, investment, and survival (Becker, 2005, p. 166). The study also provides evidence that the Pollution Abatement Costs and Expenditures data released by the Census Bureau may have certain limitations that do not fully capture the costs of regulations.

Shadbegian and Gray (2005) also adopt a micro-data set. In particular, Shadbegian and Gray (2005) employ a production function approach to investigate the impact of pollution abatement expenditures on productivity, using plant-level data for the 1979-1990 period in the oil, paper, and steel industries in the U.S. They separate inputs (capital, labor, and materials) into abatement and production components and find little evidence to suggest that abatement inputs contribute to production (except for the paper industry) and not much evidence that abatement inputs significantly reduce the productivity of other inputs. In another study, Duffy-Deno (1992) uses a sample of 63 SMSAs for the years 1974, 1978, and 1982 to investigate whether regions in the U.S. characterized by relatively higher compliance costs may also be characterized by relatively lower levels of manufacturing employment and earnings. The evidence in this study is modestly suggestive of possible adverse employment effects from pollution abatement costs.

With this brief background, the present study seeks to determine empirically whether higher pollution abatement costs lower the level of manufacturing employment in the U.S.

The analysis adopts state-level data and provides a cross-section analysis for the year 2000, the most recent period for which all of the variables in the analysis are currently available.

3. Framework of Analysis

This study seeks to determine for the U.S. the impact of pollution abatement costs on the level of employment in the manufacturing sector in each state, expressed as a percentage of total non-farm
employment in each state (PCMANUF). That employment level is
determined by the interaction of labor demand and labor supply forces
as they pertain to U.S. manufacturing. Clearly, then, the independent/
explanatory variable measuring pollution abatement operating costs
is of central interest for this study. Pollution abatement operating
costs, as opposed merely to pollution abatement capital costs, include
“…relevant salaries and wages, parts and material, fuel and electricity,
capital depreciation, contract work, and equipment leasing” associated
per se with the effort to comply with pollution abatement regulations
(Becker, 2005, p. 149).

Based on conventional microeconomic theory, it is logical to
expect that, ceteris paribus, the national regulatory requirements
for installation and operation/maintenance of pollution abatement
equipment by manufacturing establishments raise their overall cost
of production. Simple application of the marginal calculus for
manufacturing firm profit maximization demonstrates how profit
maximization in the absence of statutorily mandated pollution
abatement yields an output level (Q*) and a corresponding employment
level (E*) where marginal revenue (MR) equals marginal cost (MC)
in the upward sloping range of the MC curve. Furthermore, it is
easily shown that the subsequent imposition of pollution abatement
measures and their correlative real direct and operating costs for the
firm yield profit-maximizing output and employment levels that are
both below Q* and E*, respectively.

Consider “R” as total revenue, “C” as total variable costs, “FC”
as total fixed costs, “Q” as output, and “E” as employment, so that
the firm seeks to maximize R(Q)−C(Q)−FC. The first- and second-
order profit maximization conditions initially are:

\[ C'(Q) = R'(Q) \quad \text{and} \quad C''(Q) > R''(Q) \quad (1) \]

The above conditions are met at some \( Q = Q^* \), which yields \( E = E^* \). With the pollution abatement costs imposed, \( C(Q) \) becomes \( C#(Q) \)
\( >C(Q) \) for all \( Q \). The profit-maximizing conditions become:

\[ C#'(Q) = R'(Q) \quad \text{and} \quad C#''(Q) > R''(Q) \quad \text{at some} \quad Q = Q_o, \quad (2) \]

which yields \( E = E_o \). Since

\[ C#'(Q) > C'(Q) \quad \text{for all} \quad Q > 0, \quad Q_o < Q^* \quad \text{and} \quad E_o < E^*, \quad (3) \]
i.e., it follows that MC=MR at a lower output level and a lower
employment level (assuming labor is a variable input). Accordingly,
this study hypothesizes that real pollution abatement operating
costs (POLLOPCADJ) have a negative impact on the level of
manufacturing employment in the U.S., ceteris paribus.
Since manufacturing firms use electrical energy in their production process, the present study employs the unit real electricity price (ELPRADJ) for the industrial sector, expressed in cents per kilowatt hour, to reflect these costs. Manufacturing firms, *ceteris paribus*, will be less likely to locate in regions with relatively higher electricity prices, whereas those firms already located in such regions will – subject to layoff contract terms – tend to operate with greater excess capacity than otherwise would be the case. Stated somewhat differently, this study postulates that higher real electricity prices negatively affect production and hence employment in the manufacturing sector, *ceteris paribus*. In yet other words, higher real electricity prices raise \( C\#(Q) \) and thereby lower \( Q \) and \( E \).

The percentage change in population (POPCH) in each state may have a positive effect on manufacturing employment in the state. This is because the greater the growth rate of population in a state, the greater the demand (local) for goods manufactured in the state and hence: (a) the greater the \( R(Q) \) for manufacturing firms already located in the state; and (b) the greater the attractiveness for manufacturing firms, especially those engaged in light manufacturing (and thereby requiring lower capital investment to establish a presence in the state), to locate in the state near the growing customer base. This implies that the new MC and MR intersection is at a higher production level and hence often at a higher employment level, *ceteris paribus*.

Average hourly earnings of production workers in manufacturing industries, adjusted for the cost of living, are used in the present study to measure the real unit price of labor. Presumably, the higher are the real average hourly earnings (AVHEADJ), the lower is the level of manufacturing employment, *ceteris paribus*. Of course, considering the high unionization rate in the manufacturing sector, there can be a time lag between when the manufacturing employer decides to decrease the number of its employees as a reaction to a higher real cost of labor and the time when it is actually able to implement this change. Nevertheless, it is expected that a rise in AVHEADJ raises \( C\#(Q) \) and hence results in a lower output and therefore a lower level of employment, *ceteris paribus*. At the extreme, this circumstance could result in one or more plant closings and/or possibly also an outsourcing of production and jobs to another country. As a variant on this outcome, assuming that firms have not been forced into bankruptcy and into closing by an “excessive” AVHEADJ, a *minimal* facility (referred to here as a “Q/R” or “quick response” facility) with very modest production and employment potential (i.e., limited productive capacity) may be maintained (if
technically practical) in order to be able to cope with that form of market demand requiring so-called Q/R output provision and delivery. Nevertheless, *ceteris paribus*, the effect of an excessively high AVHEADJ in a state (considered, naturally, in a global context) is the same: less production and employment in the state.

As a control variable, the variable COLLEGEGRAD, the percent of the resident population in a state with at least a college degree, is included in the model. This variable controls for the fact that this segment of the population is, given its opportunity costs, largely unavailable for manufacturing employment. This should reduce the supply of labor to which manufacturing firms have access and result in a labor shortage for manufacturing firms, which now may need to substitute other factors of production for labor in the production process, thereby raising C#(Q) and lowering Q and E levels. Of course, as with the case of an excessively high AVHEADJ, manufacturing firms *may* simply cut production and employment in the state completely and outsource the production (and jobs) to another nation. Alternatively, in the latter case, as with the firm’s response to an excessively high AVHEADJ, the firm may choose also to maintain a Q/R facility, i.e., a *minimal* production and employment facility in the state with capacity levels far below those historically maintained, simply in order to fill Q/R orders for their manufactured products.

A dummy (binary) variable (INDUMMY) is introduced into the study as a *control variable* for states with more light industries and more service-oriented industries, such as Sunbelt states. The latter states historically have had a much lower concentration of manufacturing establishments than states in other regions of the U.S., especially the Midwest and the Northeast. Naturally, it is expected that a higher concentration of manufacturing establishments in a state generates a higher level of manufacturing employment in the state, *ceteris paribus*.

Finally, the present study investigates whether manufacturing labor supply is positively affected by the number of foreign-born immigrants in a state. Considering the not-uncommon limitations on job opportunities available for immigrants entering the U.S., employment in the manufacturing sector may be an attractive opportunity. A larger number of immigrants increases competition for the manufacturing jobs, i.e., increases available labor supply, which helps to reduce the growth rate of manufacturing industry labor costs [especially, as found in Cebula (1983), in right-to-work states] and acts to reduce C#(Q) and to elevate Q and E for manufacturing firms.
4. Model and Data

The model of the determinants of employment in manufacturing (as a percentage of total non-farm employment) across 50 states in the year 2000 involves estimating the following reduced-form equation for state j:

\[
PCMANUF_j = a_0 + a_1 ELPRADJ_j + a_2 POPCH_j + a_3 POLLOPCADJ_j \\
+ a_4 AVHEADJ_j + a_5 COLLEGEGRADJ_j + a_6 INDUMMY_j \\
+ a_7 IMMIGR_j + u
\]  

(4)

where:

the index used to “adjust” three of the explanatory variables for interstate living-cost/price-level differentials was obtained from the following source:
http://www.missourieconomy.org/indicators/cost_of_living/index.stm

and where:

PCMANUF_j = employment in manufacturing in each state, as a percentage of total non-farm employment in each state, in the year 2000.
Source: U.S. Census Bureau (2001, Table 608);

\[a_0 = \text{constant};\]

ELPRADJ_j = average unit electricity price for the industrial sector, expressed in cents per kilowatt hour in each state in the year 1999, adjusted by the cost of living index in each state.
Source: U.S. Energy Information Administration (2000, Form EIA-861);

POPCH_j = percentage change in the total population in each state from 1990 to 2000.
Source: U.S. Census Bureau (2001, Table 18);

POLLOPCADJ_j = pollution abatement operating costs in each state in the year 1999, divided by the manufacturing value added in each state, adjusted by the cost of living index in each state.
Sources: U.S. Census Bureau (1999; 2001, Table 975);

AVHEADJ_j = average hourly earnings for production workers in manufacturing industries in each state in the year 1999, adjusted by the cost of living index in each state.
Source: U.S. Census Bureau (2001, Table 975);
COLLEGEGRAD$_j$ = percentage of the adult population in each state age 25 years and older with at least a bachelors degree in year 2000. 
Source: U.S. Census Bureau (2001, Table 219);

INDUMMY$_j$= a binary variable designed to proximately measure the relative concentration of manufacturing establishments in each state in the year 1999 (INDUMMY=0 if the concentration of manufacturing establishments in a state is more than one standard deviation below the mean concentration of manufacturing establishments across states; otherwise, INDUMMY=1).
Source: U.S. Census Bureau (2001, Table 973);

IMMIGR$_j$= number of legal immigrants admitted by state in the year 1998, expressed as a percentage of the total population in each state in 1998.
Sources: U.S. Census Bureau (2001, Tables 9, 17);

u = stochastic error term.

5. Empirical Findings

Table 1 provides the results of two ordinary least squares (OLS) estimations, one for equation (4) and another for a variant of equation (4), after adopting the White heteroskedasticity correction. The two specifications, found in columns (a) and (b) of Table 1, differ slightly in the combination of explanatory variables. In both estimates, all of the independent variables returned the expected signs on their respective coefficients. In estimate (a), five of the estimated coefficients are significant at the one percent level, and one is significant at the five percent level. Similarly, in estimate (b), five estimated coefficients are significant at the one percent level, and one is significant at the five percent level. R-squared values are in the range of 0.65 to 0.67, which means that roughly two-thirds of the variation in the dependent variable was explained by the independent variables in each model. The F-statistics are significant at the one percent level, attesting to the overall strength of the models.

The estimated coefficients on the POPCH variable are positive, as hypothesized, and significant in both estimates at the one percent level in both specifications. These findings reflect the growth in commodity demand in those states having the greatest population growth, a commodity demand that typically includes to at least some
degree goods produced in those states. Although exhibiting the expected negative sign, the coefficient on the variable ELPRADJ turned out to be insignificant, so it was dropped in the second specification. The coefficients on the AVHEADJ variable in both estimates are negative, as hypothesized, and significant at beyond the five percent level. Thus, it appears that higher real average hourly earnings of production workers act to decrease the level of employment. The COLLEGEGRAD variable returned a negative sign on its coefficient and is significant at the one percent level in both specifications. This finding is consistent with the Duffy-Deno (1992) findings and implies that a greater percentage of a state’s population with a college degree or higher has a negative impact on manufacturing employment per se. The estimated coefficient on the control variable INDUMMY is positive, as hypothesized, and significant at the one percent level in both estimates. Not surprisingly, those states having a higher concentration of manufacturing establishments also

<table>
<thead>
<tr>
<th>Variable</th>
<th>(a)</th>
<th>(b)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>0.075</td>
<td>0.028</td>
</tr>
<tr>
<td>POLLOPCADJ</td>
<td>-358.541</td>
<td>-349.265</td>
</tr>
<tr>
<td></td>
<td>(-6.68)**</td>
<td>(-6.63)**</td>
</tr>
<tr>
<td>POPCH</td>
<td>+0.140</td>
<td>+0.126</td>
</tr>
<tr>
<td></td>
<td>(+4.88)**</td>
<td>(+4.68)**</td>
</tr>
<tr>
<td>ELPRADJ</td>
<td>-0.477</td>
<td>-----------</td>
</tr>
<tr>
<td></td>
<td>(-1.45)</td>
<td></td>
</tr>
<tr>
<td>AVHEADJ</td>
<td>-0.777</td>
<td>-0.879</td>
</tr>
<tr>
<td></td>
<td>(-2.32)*</td>
<td>(-2.53)*</td>
</tr>
<tr>
<td>COLLEGEGRAD</td>
<td>-0.004</td>
<td>-0.004</td>
</tr>
<tr>
<td></td>
<td>(-4.00)**</td>
<td>(-4.03)**</td>
</tr>
<tr>
<td>INDUMMY</td>
<td>+0.032</td>
<td>+0.033</td>
</tr>
<tr>
<td></td>
<td>(+3.13)**</td>
<td>(+3.21)**</td>
</tr>
<tr>
<td>IMMIGR</td>
<td>+0.055</td>
<td>+0.058</td>
</tr>
<tr>
<td></td>
<td>(+2.72)**</td>
<td>(+2.79)**</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.67</td>
<td>0.65</td>
</tr>
<tr>
<td>Adj. R-squared</td>
<td>0.61</td>
<td>0.60</td>
</tr>
<tr>
<td>F-statistic</td>
<td>11.93</td>
<td>13.30</td>
</tr>
</tbody>
</table>

** Statistically significant at the one percent level and beyond.
* Statistically significant at the five percent level.
have higher levels of manufacturing employment. The estimated coefficient on the IMMIGR variable is positive and significant at the one percent level in both cases. It appears that immigrants may increase competition for the manufacturing jobs, leading to increased manufacturing employment.

Finally, the most important finding of this study is that pollution abatement operating costs do have an adverse effect on U.S. manufacturing employment. The estimated coefficient on variable POLLOPCADJ is negative and significant at far beyond the one percent level in both estimates. This finding contradicts a number of previous studies, which find variables measuring pollution abatement expenditures as insignificant factors in plants’ production and employment related decisions [Duffy-Deno (1992), Shadbegian and Gray (2005), Conrad and Morrison (1989)].

6. Conclusion

A number of studies in recent years have investigated the impact of environmental regulation on manufacturing activities. However, there is no general consensus on the nature of this impact. A common finding is that pollution abatement expenditures do not have a significant impact on the plant’s productivity level, level of earnings, profitability, or employment. In fact, some proponents of environmental regulations believe that “…stricter regulations are not imposing any costs on firms, because such regulations encourage firms to be more productive, offsetting the direct costs of abatement…” (Shadbegian and Gray, 2005, p. 207). Although the latter may be true to a certain extent, i.e., in certain cases, the findings of the present study strongly suggest that, overall, pollution abatement costs do have a statistically significant negative impact on the level of manufacturing employment. Thus, it follows that the effort to limit or control pollution does in fact have a significant cost associated with it. Clearly, U.S. policymakers must become more circumspect in their formulation of anti-pollution policies.

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http://www.missourieconomy.org/indicators/cost_of_living/index/stm


ABSTRACT

This study empirically investigates whether pollution abatement costs have a negative impact on manufacturing employment in the U.S. Given that during the last quarter of a century, spending on environmental protection in the U.S. has grown even faster than has spending on healthcare, the social costs of pollution abatement efforts warrant attention. Conventional microeconomic theory suggests that there is a trade-off between environmental protection expenses and manufacturing activity, i.e., higher pollution abatement compliance costs borne by industries may contribute to plant shutdowns, lower production levels, and/or lack of investment, thereby leading to layoffs. However, improved environmental conditions may facilitate economic growth in regions with less pollution by attracting migration and may also serve to improve health status of its residents as well as help to protect the integrity of the environment. In any case, the existing literature offers no consensus on the impact of environmental protective measures on manufacturing employment in the U.S. Applying cross-sectional analysis for all 50 states for year 2000, this study finds empirical that pollution abatement costs have a statistically significant negative effect on employment in the U.S. manufacturing sector.

Keywords: Pollution abatement, regulatory costs, manufacturing employment

JEL Classification: L51, D62, D24

RIASSUNTO

L’impatto dei costi per la riduzione dell’inquinamento sull’occupazione manifatturiera negli Usa

Questo articolo studia empiricamente se i costi per la riduzione dell’inquinamento hanno un impatto negativo sull’occupazione manifatturiera negli USA. Considerato che nell’ultimo quarto di secolo la spesa per la protezione dell’ambiente negli Stati Uniti è cresciuta persino più di quanto non sia cresciuta la spesa sanitaria, i costi sociali dei tentativi compiuti per la diminuzione dell’inquinamento giustificano una certa attenzione. Teorie microeconomiche convenzionali suggeriscono che sia un trade-off tra le spese per la protezione ambientale e l’attività produttiva: i maggiori costi sostenuti dalle industrie per adeguarsi agli standard di riduzione dell’inquinamento possono contribuire alla chiusura degli impianti, ad abbassare i livelli di produzione e/o a provocare una riduzione di investimenti, con conseguenti licenziamenti. Tuttavia, condizioni ambientali migliori possono facilitare la crescita economica attirando flussi migratori nelle regioni meno inquinate e possono essere utili a migliorare lo stato di salute degli abitanti e a preservare l’integrità dell’ambiente. In verità, studi già effettuati non appoggiano l’ipotesi che l’impatto delle misure protettive per l’ambiente influenzi l’occupazione manifatturiera negli USA. Attraverso un’analisi cross-section relativa al 2000 in tutti i 50 stati USA, questo studio riscontra che i costi per la riduzione dell’inquinamento hanno un effetto negativo statisticamente significativo sull’occupazione nei settori manifatturieri.