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Regulatory Regime Changes Under Federalism: Do States Matter More?

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1. INTRODUCTION

After the passage of the 1970 Clean Air Act Amendments and 1972 Clean Water Act Amendments the United States has been able to achieve substantial improvements in both air and water quality due in large part to increasing stringency of regulation, which has caused continuous declines in emissions from industrial sources. In the United States environmental policymaking is conducted via a federalist system with the federal U. S. Environmental Protection Agency (EPA) setting the stringency of regulation and states' implementing and enforcing the regulations. The ability of states to implement and enforce regulations provides them with a considerable amount of discretion (e.g. setting water permit discharge levels, number of plant inspections).

State discretion potentially has both pros and cons. First, this discretion allows each state to develop their own methods of regulating, thereby providing opportunities to develop more innovative policies, which can lead to more net benefits from regulation. However, there is potential for such discretion to be abused. For example, states may free ride on their neighbors by allowing plants located near state borders (border plants) to emit more pollution than non-border plants – Sigman (2005), Helland and Whitford (2003), and Gray and Shadbegian (2004) all find evidence of this behavior.[1] Finally, states may choose to be less rigorous in terms of enforcing regulations in an effort to attract new businesses to the state, resulting in a so-called "race to the bottom." [2,3]

[1] In particular, Sigman finds that states allow plants to emit greater amounts of water pollution when that pollution crosses state borders via interstate rivers. Helland and Whitford, using annual (1987-1996) county-level TRI data, find that facilities located in counties on state borders (border counties) emit significantly more air and water toxics than facilities located in non-border counties. Gray and Shadbegian (2004) find that pulp and paper mills whose pollution impacts the population of neighboring states emit more pollution.
[2] See Sigman (2003) for more information on the discretionary powers of the states.
[3] There is a large literature examining the "race to the bottom"; see Oates (2001).

We would expect states to differ in their ability and/or desire to implement and enforce EPA regulations. Therefore, it is not clear whether making national regulations stricter in such a federal setting will increase or reduce differences across states in effective regulatory stringency. Stricter national rules may "raise the bar" and force less stringent states to make greater changes. On the other hand, since much of regulatory activity is done at the state level, stricter regulations at the national level may strengthen the bargaining power of regulators in more stringent states, enabling them to increase their stringency more than other states.

In 1998 the EPA promulgated the first integrated, multi-media regulation – known as the "cluster rule" (CR). The goal of the CR was to reduce the pulp and paper industry's toxic releases into the air and water. By promulgating both air and water regulations at the same time EPA made it possible for pulp and paper mills to select the best combination of pollution prevention and control technologies, with the hope of reducing the regulatory burden.

We test the impact of the air and water regulations in the CR, using data from 1996-2005 for 150 pulp and paper mills, including information on both toxic and conventional pollutants. We include a wide range of control variables shown in previous research to affect plant environmental performance, including plant- and firm-level characteristics and regulatory activity. We find significant reductions in total toxics and air toxics around the time that the CR was implemented, though not for water toxics. However, plants identified as facing stricter CR rules do not generally show larger reductions in toxics. We find no evidence for large reductions in conventional pollutants around the CR implementation date, but do observe significant positive correlations in residuals across the different pollutants, suggesting the presence of unmeasured factors that may improve (or worsen) a plant's performance across the board.

Finally, we find some evidence that the differences across states in regulatory stringency may have been lessened by EPA's adoption of the CR. Plants located in states with more political support for stringent regulation have lower toxic releases on average throughout the period, but they have a smaller decline in toxic releases over time, as shown by our 5-year-change analysis. This suggests that some of the reductions required by the CR had already been implemented in high-stringency states, so the CR had a greater impact on plants in lower-stringency states.

Section 2 provides background information on pollution from the pulp and paper industry and a brief history of the Cluster Rule. Section 3 reviews the relevant literature, while section 4 presents a model of the determinants of environmental performance. Section 5 discusses the data and empirical methodology. Section 6 presents the results, followed by concluding comments in section 7.

2. REGULATING THE PULP AND PAPER INDUSTRY

During the past 35 years environmental regulation on the U.S. manufacturing sector has become increasingly tougher in terms of both stringency, and enforcement and monitoring. Prior to the creation of the federal Environmental Protection Agency (EPA) in the early 1970's environmental rules were predominantly enacted at the state level, and were not rigorously enforced. Since the early 1970's the federal government has been the principal player in developing stricter regulations and promoting a greater emphasis on enforcement, much of which is still performed by state regulatory agencies under varying degrees of federal supervision.

The evolving stringency of environmental regulation has imposed large costs on traditional 'smokestack' industries, like the pulp and paper industry, which is one of the most highly regulated industries due to the large volumes of both air and water pollution it generates.

Although these regulatory efforts have proven costly to the pulp and paper industry they have also been successful in reducing the emissions of conventional air and water pollutants with the advent of secondary wastewater treatment, electrostatic precipitators, and scrubbers. Furthermore, some mills have gone beyond these end-of-pipe control technologies, and have redesigned their production process, *e.g.* more closely monitoring material flows to further reduce emissions. In general these modifications have been much easier to achieve at newer plants, which were, at least to a certain extent, designed with pollution controls in mind – some old pulp mills were intentionally constructed over rivers, so that any spills or leaks could run through holes in the floor for 'easy disposal.' These rigidities can be partially or completely offset by the propensity for most regulations to incorporate grandfather clauses exempting existing plants from the most stringent requirements – for example, until more recent standards limited their NOx emissions, most small old boilers were exempt from air pollution regulations.

The entire pulp and paper industry faces significant levels of environmental regulation. However, plants within the industry face differential impacts from regulation, depending in part on their technology (pulp and integrated mills vs. non-integrated mills[4]), age, location, and the level of regulatory effort directed at the plant. Previous studies, including Gray and Shadbegian (2003), have shown that the most important determinant of the regulatory impact on a plant is whether or not the plant contains a pulping facility, since the pulping process (separating the fibers need to make paper from raw wood) is much more pollution intensive than the paper-making process.[5] Different pulping processes result in different types of pollution: mechanical pulping uses more energy, generating air pollution from a power boiler, while chemical pulping

[4] Integrated mills produce their own pulp and non-integrated mills purchase pulp or use recycled wastepaper.

[5] The two main environmental concerns during paper-making stage are air pollution if the mill has its own power plant and the residual water pollution generated during the drying process.

could generate water pollution from spent chemicals, some of them potentially toxic. In addition, if a white paper product is desired the pulp must be bleached. The Kraft chemical pulping process was originally considered to be relatively low-polluting in terms of conventional air and water pollution. Unfortunately, when combined with elemental chlorine bleaching, it can create chloroform, furan, and trace amounts of dioxin, raising concerns over toxic releases that contributed, at least indirectly, to the development of the Cluster Rule.

An incident in Times Beach, Missouri (located near St. Louis) helped raise concerns about toxic pollutants in general, and dioxin in particular. On December 5th, 1982 the Meramec River flooded Times Beach, contaminating nearly everything in the town with dioxin that had been deposited by dust spraying in the early 1970's. The Center for Disease Control concluded that the town was uninhabitable and in 1983 the US EPA bought Times Beach and relocated its residents, reinforcing in the public mind the dangers of dioxin.

In the aftermath of the Times Beach incident two influential environmental groups, the Environmental Defense Fund and the National Wildlife Federation, sued the EPA for not adequately protecting the U.S. public from the risks of dioxin. As part of a 1988 settlement with the environmental groups the EPA agreed to study the health risks of dioxin and to set regulations to reduce dioxin emissions. Ten years later, EPA implemented regulations that included dioxin reductions, as part of the Cluster Rule.

The Cluster Rule

In 1998 the EPA promulgated the first integrated, multi-media regulation – known as the "cluster rule" (CR) – to protect human health by reducing the pulp and paper industry's toxic releases into the air and water. The Cluster Rule was scheduled to take effect (for the most part) three years later, in April 2001. By promulgating both air and water regulations at the same time EPA allowed pulp and paper mills to consider multiple regulatory requirements at one time, hoping to reduce the aggregate regulatory burden on the mills. The more stringent (technology based) air regulations in the CR call for substantial reductions in hazardous air pollutants (reduce by 59%), sulfur (47%), volatile organic compounds (49%) and particulate matter (37%). The more stringent (technology based) water regulations in the CR call for a 96% reduction in dioxin and furan, and a 99% reduction in chloroform. EPA estimates that approximately 490 pulp and paper mills are subject to the new CR air regulations. Furthermore, any pulp and paper mill that has the potential to emit ten tons per year of any particular hazardous air pollutant (HAP) or an aggregate of 25 tons per year of all HAPs is subject to the even more stringent maximum achievable control technology (MACT) standards for HAPs, under the National Emission Standards for Hazardous Air Pollutants (NESHAP). EPA estimated that 155 of the 490 affected pulp and paper mills would be subject to the new MACT standards. Finally, pulp and paper mills that chemically pulp wood (96 of the 155) are also required to meet a new set of effluent standards, defined as best available technology economically achievable (BAT) standards. These effluent standards are to take effect when the plant's water pollution discharge permit is renewed, which spreads the effective date out over several years (since many water permits last for five years). Thus we have a set of regulations affecting multiple pollution media, with different sets of plants facing different stringency on the different media, with some of the stringency changes occurring at different times for different plants. This allows us multiple dimensions along which to test the impact of the Cluster Rule.

3. LITERATURE REVIEW

Much of the empirical research on the impact of environmental regulation has focused on the effect of reported pollution abatement costs on productivity.[6] However, there is a growing literature, including studies by Magat and Viscusi (1990), Gray and Deily (1996), Laplante and Rilstone (1996), Nadeau (1997), Shadbegian and Gray (2003,2006), Earnhart (2004a,2004b), Schimshack and Ward (2005), and Gray and Shadbegian (2005,2007), which examines the environmental performance of polluting plants with respect to conventional air and water pollutants. Some studies have focused on the effectiveness of enforcement activities (mainly carried out by the states) in terms of raising compliance rates or lowering emissions. Gray and Deily (1996) and Gray and Shadbegian (2005) find that plants that face greater levels of air enforcement activity by regulators have higher compliance rates, while Nadeau (1997) finds these plants spend less time in non-compliance. In terms of the impact of water regulations, Magat and Viscusi (1990) and Laplante and Rilstone (1996) find that greater levels of water pollution enforcement activity result in lower water discharges. Furthermore, Shimshack and Ward (2005) find that one additional fine in a state for violating a water standard leads to roughly a two-thirds reduction in the statewide violation rate in the following year, suggesting that the regulator's enhanced reputation has a general deterrence effect leading to increased environmental performance at other plants in the state as well as at the fined plant. Earnhart (2004a) analyzes the impact of EPA regulations on the level of environmental performance of municipal wastewater treatment facilities in Kansas finding that the *threat* of federal inspections and enforcement action and the *threat* of state enforcement action significantly increase environmental performance. In a second study, Earnhart (2004b) finds that both income of a

[6] Research on the productivity effects of environmental regulation include Denison (1979), Gollop and Roberts (1983), Barbera and McConnell (1986), Gray (1986, 1987), Boyd and McClelland (1999), Berman and Bui (2001), Gray and Shadbegian (2002, 2003), and Shadbegian and Gray (2005,2006).

community and its political activism tend to significantly reduce discharge rates of municipal wastewater treatment plants in Kansas.

Shadbegian and Gray (2003) perform a more detailed examination of the environmental performance of 68 pulp and paper mills, finding that air emissions are significantly lower at plants: which have a larger air pollution abatement capital stock; which face more stringent local regulation; and which have higher production efficiency. Furthermore, they find a negative residual correlation between emissions and efficiency, providing evidence that plants which are more efficient in production are also more efficient in pollution abatement.

Shadbegian and Gray (2006) examined the impact of regulatory stringency on plants in the pulp and paper, steel, and oil industries and find that plants facing more local regulatory stringency had better (air and water) environmental performance. Finally, Gray and Shadbegian (2007) examine spatial factors affecting environmental performance of polluting plants, measured by air emissions and regulatory compliance. They find that increased regulatory activity has significant effects for compliance, but for not emissions. In particular, they find that increased regulatory activity has the expected effect of increasing compliance with air regulations, both at the inspected plant and at neighboring plants, but only for plants operating in the same state, indicating the importance of jurisdictional boundaries.

In addition to the large literature that now exists on the impact of regulation on the environmental performance of polluting plants with respect to conventional pollutants there is a growing literature which examines the impact of different EPA programs and community characteristics on toxic emissions. For example, Khanna and Damon (1999) find evidence that participation in EPA's voluntary 33/50 Program (a program under which facilities volunteered to decrease a certain specified set of their toxic releases by 33% by 1992 and 50% by 1995 relative to their 1988 levels) led to a significant decline in these toxic releases over the period 1991-93. On the other hand, Bui (2005) examines whether or not TRI induced public disclosure contributed to the decline in reported toxic releases by oil refineries. Bui finds some evidence that the public disclosure provisions of TRI may very well have caused some reductions in reported TRI releases. However she also finds evidence that reductions in toxic releases are a byproduct of more traditional command and control regulation of emissions of *non*-toxic pollutants.

In two additional studies which belong to the so-called environmental justice (EJ) literature, Arora and Cason (1999) and Wolverton (2002) examine the impact of community characteristics on toxic emissions. Arora and Cason, analyzing 1993 TRI emissions, find evidence race is significantly positively related to TRI releases, but only in non-urban areas of the south. Wolverton (2002) finds larger TRI reductions in minority neighborhoods than in non-minority neighborhoods in Texas, precisely the opposite of the assertions of many earlier entries in the EJ literature.

4. DETERMINANTS OF ENVIRONMENTAL PERFORMANCE

An individual manufacturing plant faces costs and benefits from complying with environmental regulation, depending on characteristics of the plant, the firm which owns the plant, and the regulatory stringency it faces. Given these constraints, the firm operating the plant maximizes profits, choosing to comply if the benefits (lower penalties, better public image) outweigh the costs (investment in new pollution control equipment, managerial attention). Regulators, in turn, allocate enforcement activity to maximize their objective function (political support, compliance levels, emissions reductions), taking into account the expected reactions of the firms to that enforcement.

There are substantial differences in pollution problems across different manufacturing plants. Difficulties in compliance might be related to a plant's production technology at the plant (e.g. pulp mills versus plants which buy pulp) or the plant's age or size. Differences in compliance behavior might also be related to the plant's productivity (proxying for economic performance and management ability). The impact of most of these plant characteristics on environmental performance could go either way: older plants might find it harder to comply with new stricter standards, but could be grandfathered; larger plants might enjoy economies of scale in pollution abatement compliance, but could also have more places that something could go wrong.

The expected direct benefit the plant receives from compliance is the avoidance of penalties. Therefore a plant's decision to comply depends on both the magnitude of the penalty and the probability of being caught in noncompliance; the latter depends on the amount of enforcement activity faced by the plant.

Environmental performance may also depend on characteristics of the firm which owns the plant, such as its financial condition. Pollution abatement can involve sizable capital expenditures, which may be more easily raised by more profitable firms. Firms with reputational investments in the product market may face an additional incentive not to be caught violating environmental rules, if their customers would react badly to the news. Firms might also differ in the quality of the environmental support that they offer their plants. A large firm, specializing in one of the highly regulated industries, is likely to have economies of scale in learning about what regulations require, and may be in a better position to lobby regulators on behalf of their plants. We cannot measure the strength of a company's environmental program, but may see some effect of firm size. In sum, a plant's compliance status depends on plant characteristics and firm characteristics, and the level and efficacy of enforcement activity directed towards it.

Based on the above discussion, we estimate a model of plant environmental performance:

$$Z_{pkt} = f_k(CLUSTER_{pkt}, STATE_{jt}, CLUSTER_{pkt}*STATE_{jt}, X_{pt}, X_{ft}, YEAR_t, u_{pkt})$$

Here Z_{pkt} measures the environmental performance of plant p at time t along dimension k, including emissions of different air and water pollutants, possibly conventional as well as toxic (note that in this context, higher values of Z would represent poorer performance, so we'd expect negative coefficients on terms that improve performance). $CLUSTER_{pkt}$ is a measure of the stringency of the Cluster Rule related regulations faced by different plants at different times, which is expected to raise environmental performance (in its simplest form, CLUSTER could be a time dummy, turned on in 2001). $STATE_{jt}$ is an index of how rigorously a state is expected to enforce environmental regulations, which is also expected to raise environmental performance. The CLUSTER*STATE interaction term allows us to test whether stricter state regulatory agencies have been differentially affected by the Cluster Rule. This effect could go either way. Plants in states with preferences for strong environmental regulation might have already implemented some of the Cluster Rule requirements, and would therefore show less of an impact from the Cluster Rule on their performance, and a positive coefficient on the interaction. Alternatively, if stricter states are always looking for ways to increase regulatory stringency, the requirements of the Cluster Rule might provide those states with further regulatory tools, allowing them to become even stricter and resulting in a negative coefficient on the interaction. The model also includes characteristics of the plant (X_p) and firm (X_f), year dummies ($YEAR_t$) to allow for changes in environmental performance or its definition over time, and other unmeasured factors (u_{pkt}).

We supplement our basic analyses of the impact of the Cluster Rule on various measures of emissions, with a seemingly unrelated regression (SUR) model. This allows us to test for correlations between the unexplained variation in different environmental performance measures, particularly for correlations across pollution media: air and water pollutants, and toxic and conventional pollutants. We would generally expect to find positive correlations across pollutants, as unobserved factors (such as management ability or local regulatory pressures) lead a plant to do better (or worse) than expected on a wide range of pollutants, but it’s possible that some plants are able to substitute one type of pollution abatement for another when redesigning their production process.

5. DATA AND EMPIRICAL METHODOLOGY

This study examines the impact of the Cluster Rule on pollution emissions for a wide range of pollutants, as well as testing whether the gap in environmental performance across plants regulated in different states has been shrinking or growing as a result of the Cluster Rule. We control for a number of other factors shown in previous research to affect plant environmental performance, including plant- and firm-level characteristics. We also include a number of other control variables designed to capture characteristics of the location of the mill that could influence the level of regulatory activity it faces.

In past studies we developed a comprehensive database of U.S. pulp and paper mills to study the impact of environmental regulation on plant-level productivity and investment. This database includes published plant-level data from the Lockwood Directory and other industry sources to identify each plant's production capacity (both pulp capacity and paper capacity), age, production technology, and corporate ownership. We add financial data taken from Compustat, identifying firm profitability and firm size.

Our pulp and paper mill data is merged with annual plant-level information on quantities of pollution for both air and water pollution and for conventional and toxic pollutants. The EPA's Toxic Release Inventory (TRI) database provides annual information on the amount and type of releases of a wide range of hazardous substances. Given that the Cluster Rule focuses on reducing toxics, we defined our sample of plants in large part as those appearing in 10 consecutive years of TRI data, from 1996 to 2005, providing us with 5 years before and 5 years after the Cluster Rule implementation in 2001. This requirement (and a few restrictions for availability of other key variables) results in a sample of 150 plants. We aggregate the TRI data to create four measures of toxic pollution: total on-site releases (including air, water, underground injection, and other land releases), air releases, water releases, and releases of chloroform.[7]

Our measures of conventional air and water pollutants come from other EPA databases. The EPA's Envirofacts and Integrated Data for Enforcement Analysis databases provide information on water pollution discharges for Biochemical Oxygen Demand (BOD) and Total Suspended Solids (TSS), covering the period from 1996 to 2002. Air pollution emissions data for particulates (PM10), volatile organic compounds (VOCs), and sulfur dioxide (SO_2) come from the National Emissions Inventory for 1996-1999 and 2002. There is not perfect overlap between the set of plants we obtained from the TRI and these databases, so our measures of conventional pollutants are only available for a subsample of the data.

Testing for an impact of the Cluster Rule requires us to identify which plants are affected

[7] Of the different chemicals targeted by the Cluster Rule, only chloroform has been recorded in the TRI for a sufficiently long time to be included in our analysis (dioxin and related compounds were not added to the TRI until 2000, by which time many plants had already achieved their reductions).

by which parts of the rule, and at what time. All of the plants in our analysis are covered by the most general part of the Cluster Rule, which calls for reductions in releases of air toxics, beginning in April 2001. EPA also published a list identifying the 155 plants with sufficiently large emissions of hazardous air pollutants to qualify for the MACT standards, and a list identifying the 96 of those plants that would face the BAT water standards. We linked those lists to the 150 plants in our database, identifying 105 MACT plants and 65 BAT plants. Because the stricter water regulations for a given BAT plant become effective when that plant renews its water discharge permit, we use water permit date information from the Envirofacts database to assign an effective date for each BAT plant (EFFECTIVE BAT). The requirements for MACT plants come into place in 2001, so the indicator for that regulation (EFFECTIVE MACT) is turned on in 2001.

We also need a measure of regulatory stringency at the state level, to test whether the Cluster Rule has tended to increase or decrease the differences in stringency across states. For this we rely on an index of the political support for environmental regulation within a state, based on the pro-environment voting of its Congressional delegation (GREEN VOTE). These data are collected and reported by the League of Conservation Voters. They provide considerable explanatory variation both across states and over time, and we have used this variable extensively in earlier research.

6. RESULTS

Table 1 presents descriptive statistics for our data. The average plant in our sample reports nearly a million pounds of toxic releases annually, of which the majority are air toxics. As noted earlier, most of the dioxin-related substances were not included in the TRI until 2000, so we focus on releases of chloroform as an indicator of activity that might generate dioxin.[8] Releases of chloroform are relatively rare, with only about one-fifth of the sample reporting any chloroform releases; this number shrank rapidly during the years between 1996 and 2005.

The 5-year-change versions of the dependent variables identify the growth (or decline) of toxic releases and other pollutants over a five-year period, designed to identify trends in pollution across the time when the cluster rule was implemented. Total toxic releases at the average plant declined by about 30 percent over five years, with air toxic releases declining by a somewhat larger amount and water toxic releases increasing. There was also a huge decrease in releases of chloroform, which was one of the targets of the Cluster Rule, as we observed earlier. In terms of conventional pollutants, we saw declines of about 20 percent for water pollutants, with larger declines for sulfur dioxide and increases for particulates and VOCs.

Our initial analysis of the toxic release data is presented in Table 2. Most of the variables in the model show significant effects and generally have the expected signs, although this is less often true for chloroform releases, which also has the lowest R-squared. A one standard deviation change in our measure of state-level political support for regulatory stringency, GREEN VOTE, is associated with a 20 percent decline in toxic releases, and about twice as large a decline in chloroform. Plant characteristics are significant, as expected, with larger pulping plants and kraft mills having more toxic releases. On the firm side, more profitable firms show generally lower releases, although larger firms do not have lower releases, as we might have expected if larger firms provide more compliance assistance to individual plants. Plants located within 50 miles of a state border have higher air and total releases, while plants located in a non-

[8] Chlorinated toxic pollutants including dioxins, chloroform, and furans are byproducts of the elemental chlorine bleaching process, being created when elemental chlorine and hypochlorite react with the lignin in wood.

attainment county (with respect to ambient particulates) have lower releases. Plants located in poor neighborhoods tend to have more releases, while those in highly-educated neighborhoods have fewer releases.

Our focus in Table 2 is on the pattern of the year dummies, to see whether toxic releases in the years after the cluster rule is implemented appear significantly different (and lower) from toxic releases in the years before implementation. Of all the toxic measures, the air toxic model comes the closest to this pattern; the results for the total toxic model are similar, not surprising since air toxics are the largest component of total toxics in our sample. We observe a large drop in releases in 2001 relative to 2000, with relatively little variation on either side of the implementation point. What variation there is fits a relatively quick adjustment period - a bit of a downturn starting in 2000 and continuing into 2002. A statistical test for coefficient equality shows essentially no difference for the coefficients within each period, and a noticeably larger difference across the periods (marginally significant for total emissions). By contrast, the chloroform releases show a substantial downward trend from the start of the pre-cluster period, with a leveling-out (at much lower levels) in the post-cluster period. We find significant differences within the pre-cluster period and between the periods, but not within the post-cluster period. This is consistent with paper manufacturers taking steps during the 1990s to phase out their use of chlorine bleaching, even before the cluster rule took effect.

Table 3 presents the results of an analysis with a more nuanced model of the impacts of the cluster rule on toxic releases (we omit a discussion of the coefficients on the control variables, which are similar to those seen in Table 2). Although we anticipate a general increase in regulatory stringency around the implementation date, different plants face different degrees of stringency, and there is some variation in the timing. Along the stringency dimension, we have some plants facing MACT air standards and/or BAT water standards, while others do not. Along the timing dimension, the more stringent water standards were to be implemented when a plant renewed its water discharge permits. Identifying the impacts of these regulatory differences is complicated, because the regulatory stringency depends on the level of releases from the plant, with the more stringent MACT rules applying to plants emitting relatively large amounts of toxics. We therefore include dummy variables indicating a plant's eligibility for the MACT or BAT rules in all the years of the data analysis, along with dummy variables (EFFECTIVE-MACT and EFFECTIVE-BAT) indicating when that part of the cluster rules became effective for that plant.

The pattern of year dummies is similar to that found in Table 2. Since we are controlling separately for the MACT and BAT standards, this indicates that other plants in the paper industry, not affected by MACT or BAT also made considerable reductions in air, chloroform, and total releases over this time period. As expected, the MACT and BAT dummies are significantly positive in the air and water toxic equations, reflecting the targeting of those additional requirements towards the largest sources within the industry. The measures of the impact of additional regulatory stringency, EFFECTIVE MACT and EFFECTIVE BAT, show weaker results. The EFFECTIVE MACT measure actually shows an increase in toxics following the implementation date. The EFFECTIVE BAT measure does show a decrease of about 30 percent in water toxics, but this is not significant.

An alternative approach to measuring the impact of the implementation is shown in Table 4, where we move to an analysis of 5-year-changes in toxic releases. Here we calculate the change in log releases over a five-year period, hopefully smoothing out some of the year-to-year fluctuations in releases and concentrating on medium-run changes that reflect improvements in plant operating procedures or investments in pollution abatement activity. The analysis includes five observations per plant for the 2001-2005 releases, each measured relative to the releases from five years earlier, 1996-2000. The intercept terms reflect the declines over the period in all the releases (except water releases). Again, we see an unexpected positive sign for plants covered by the MACT air regulation, suggesting that they are reducing their air toxic releases by less than other, non-MACT plants. The BAT water regulations are associated with a greater reduction in water toxics than that achieved by plants facing less stringent regulation.

Another coefficient of interest in Table 4 is GREEN VOTE, reflecting differences in the amount of toxic reductions achieved by plants in states with different political support for stringent regulations. This coefficient is positive in all models, and significant for air and total toxics. The coefficient found on GREEN VOTE for air toxics here (+0.012) is comparable in magnitude to that found in Table 1 (-0.015). Taken together, these results suggest that plants located in states with more political support for strict environmental regulations achieved lower levels of toxic releases in the years before the cluster rule was implemented, but that plants located in other, less stringent states, have tended to catch up, at least in part, after the cluster rule was implemented.

In Tables 5 and 6 we turn our attention to discharges of conventional air and water pollutants, considering three air pollutants (PM10, SO2, and VOC) and two water pollutants (BOD and TSS). While conventional pollutants are not directly addressed by the cluster rule, EPA had suggested that the steps taken under the cluster rule to reduce air toxic releases could also lead to some reductions in other air pollutants, most notably particulates and VOCs. We defined our dataset based on having complete toxic release data, not complete air and water pollution data, so the analyses here are being done on subsamples of our plants. We have 144 plants with a total of 599 plant-years of air pollution data and 107 plants with 749 plant-years of water pollution data; the water pollution data came with complete 1996-2002 data for each plant, while the air pollution data came in two sets, one for 1996-1999 and the other for 2002, with incomplete overlaps between them, so that we can calculate long changes in the air pollution measures for only 104 plants.

The various control variables in Table 5 show impacts that are broadly similar to those found earlier for toxic releases. Both air and water pollution levels are significantly lower in states with more support for regulatory stringency, as measured by GREEN VOTE: a one standard deviation higher GREEN VOTE value is associated with 20-50 percent lower levels of emissions. Plant characteristics are again significant, with larger pulp mills showing higher pollution levels. Firm characteristics are less significant, and the plant location and demographics variables for water pollution are more consistent with those found for toxics, with plants near state borders and in poor or less well-educated neighborhoods having higher pollution levels.

Turning to the impact of the cluster rule, in Table 5 we apply an analysis similar to that used in Table 3, although our ability to measure any effects is hampered by limited data in the post-cluster period - a single year (2002) for air pollution and only two years (2001-2002) for water pollution. In addition to year dummies, we also include the detailed measures of which plants were affected by different regulatory stringencies under the cluster rule and at different times. Unlike the results we found for toxic releases, there are no significantly negative year dummies for any of the air or water pollutants. In fact, the water pollutants seem to be decreasing over the years while the air pollutants are staying the same or increasing, the opposite of what we found for toxics.

Looking at the more detailed measures, MACT and BAT plants have higher emissions of conventional pollutants to go with their higher emissions of toxic pollutants. This relationship is strongest for particulates and VOCs in MACT plants, which provides indirect support for EPA's suggestion of where to look for a toxic-conventional link. In fact, we have some direct evidence of an effect in this area with the negative coefficients on EFFECTIVE MACT, although these effects are not significant. For water pollutants, the corresponding coefficients are positive, though again not significant.

These indications of a connection between the cluster rule and reductions in conventional pollutants do not carry over to the analysis of long differences in air and water pollution presented in Table 6. Here all of the detailed regulatory stringency measures have positive coefficients. Few of the other coefficients are significant, although the reduction in air pollutants seems to be smaller at plants in states that have more political support for regulation, again suggesting that further reductions may be more difficult to achieve in those states.

Finally, we examine the relationship between different pollutants at the same plant, both in terms of levels and changes over time. Table 7 shows the results of a seemingly unrelated regression analysis focusing on the toxic release data for air, water, and chloroform. We see a significant set of correlations across the residuals from the different equations. This suggests the presence of unmeasured factors influencing the different pollutants in the same direction, perhaps including the quality of plant management or local pressures from regulators and plant neighbors. When we turn to the changes in air, water, and chloroform releases over a five-year period, we continue to find a significant positive correlation between unexplained changes in air and water releases (and a significant overall correlation among the residuals), but changes in chloroform releases are no longer strongly related to air and water changes.

Because our data for conventional air and water pollutants is only available for a subsample of our plants, we chose to maintain our sample size by estimating each model independently of the others, calculating the residual, and then looking for correlations across the residuals for different pollutants at the same plant. Table 8 shows the correlations for the levels of toxic and conventional pollutants. We find consistently positive, and generally significant, correlations across all the pollutants. The results for the changes, in Table 9, are somewhat weaker, but still show positive relationships in most cases. This suggests that plants with greater than expected reductions in one pollutant also have unexpected reductions in other pollutants.

7. CONCLUDING REMARKS

In this paper we examine the impact of the Cluster Rule on the environmental performance of plants in the pulp and paper industry. This was EPA's first integrated, multi-media regulation, announced in 1997, promulgated in 1999, and effective in 2001 (with some variation in effective date, as described above). Using a sample of 150 pulp and paper mills, we test for changes in emissions of toxic pollutants. We find significant reductions in total toxics and air toxics around the time that the CR was implemented, though not for water toxics. These reductions in air and total toxics are highly concentrated around the time of implementation, with little evidence of anticipation or delay in responding to the implementation date. By contrast, the very large reduction in chloroform releases begins well before the CR effective date, indicating some anticipation of the new rules, possibly triggered by non-regulatory factors affecting the industry, such as pressure from customers and environmental organizations to reduce dioxin.

When we examine the plant's CR status in more detail, plants identified as facing stricter CR rules, on either the air (MACT) or water (BAT) side, do not show consistently greater reductions in those toxic releases. We find no evidence for large reductions in conventional pollutants around the CR implementation date, but do observe significant positive correlations in residuals across the different pollutants, suggesting the presence of unmeasured factors that may improve (or worsen) a plant's environmental performance across the board.

Finally, we find some evidence that the differences across states in regulatory stringency may have been lessened by EPA's adoption of the CR. Plants located in states with more political support for stringent regulation have lower toxic releases on average throughout the period, but they have a smaller decline in toxic releases over time, as shown by our 5-year-change analysis. This suggests that some of the reductions required by the CR had already been implemented in high-stringency states, so the CR had a greater impact on plants in lower-stringency states.

These results should be recognized as preliminary, based in part on the limitations of the datasets being used here. We intend to expand the years of data on conventional air and water pollutants incorporated in the analysis, to get a stronger test for reductions in those pollutants after the CR was implemented. We also intend to test alternative measures of state regulatory stringency, to get a better handle on how a regulatory structure under federalism responds to changes in centrally-mandated stringency as new regulations are introduced. Finally, an innovative provision in the CR is the ability of plants to opt into the Voluntary Advanced Technology Incentives Program (VATIP), agreeing to further reductions (beyond those required by the CR) in the future, but extending their effective compliance date beyond April 15th, 2001. We have not yet located a list of plants that joined the VATIP (despite several contacts with EPA), but hope to add this information to the analysis, so we can get a more precise estimate of the effective date of the CR for all affected plants.

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TABLE 1

DESCRIPTIVE STATISTICS
(N=1500 unless otherwise noted)

VARIABLE	MEAN (STD DEV)	{log mean,std}	5-YEAR-CHANGE
DEPENDENT VARIABLES			
TOTAL AIR EMISSIONS[a] Total toxic air emissions (in pounds)	761863.4 (851008.4)	{12.35,2.57}	{-0.379,1.6}
TOTAL WATER EMISSIONS[a] Total toxic air emissions (in pounds)	57229.2 (149833.0)	{8.15,4.06}	{0.383,2.5}
CHLOROFORM[a] Total Chloroform emissions (in pounds)	67861.8 (69465.7)	{2.26,4.39}	{-2.648,4.7}
TOTAL TRI EMISSIONS[a] Total toxic emissions (in pounds)	914882.9 (984479.9)	{12.71,2.12}	{-0.287,1.3}
PM10 (N=599)[a] Tons of particulate emissions per year	488.3 (625.8)	{5.20,1.85}	{0.147,1.2}
SO_2 (N=599)[a] Tons of sulfur dioxide emissions per year	2409.7 (3905.8)	{6.49,2.24}	{-0.321,1.8}
VOCS (N=599)[a] Tons of volatile organic compound emissions per year	686.8 (879.6)	{5.66,1.60}	{0.366,1.7}
BOD (N=749)[a] Biological oxygen demand discharged	4784.8 (5007.7)	{7.86,1.31}	{-0.193,0.8}
TSS (N=749)[a] Total suspended solids discharged	7308.1 (8813.6)	{8.22,1.36}	{-0.191,1.0}
EXPLANATORY VARIABLES			
MACT Dummy variable =1 for plants which must install maximum available control technology to abate toxic air emissions	0.7 (0.5)		
EFFECTIVE-MACT Dummy variable =1 for MACT plants after 2000	0.35 (0.5)		
BAT Dummy variable =1 for plants which must install best available technology to abate toxic water releases	0.43 (0.5)		
EFFECTIVE-BAT Dummy variable =1 for BAT plants with timing based on date of plant's water permit	0.25 (0.4)		

TABLE I (cont)

GREEN VOTE State pro-environment Congressional voting (League of Conservation Voters)	43.12 (22.05)	
KRAFT Dummy variable =1 for plants which use the kraft pulping process	0.59 (0.49)	
PULP CAPACITY[a] Plant capacity - tons of pulp per day	761.4 (724.4)	(4.92,3.04)
PAPER CAPACITY[a] Plant capacity - tons of paper per day	831.9 (724.6)	(5.40,2.71)
OLD PLANT Dummy variable =1 for plants opened before 1960	0.63 (0.48)	
RETURN ON ASSETS Firm's rate of return on assets (Compustat)	0.81 (2.61)	
EMPLOYMENT Firm's number of employees in 1000's (Compustat)	20.74 (31.97)	
BORDER PLANT Dummy =1 for plants located within 50 miles of a state border	0.27 (0.44)	
POOR Fraction of the population within 50 miles of the plant living below the poverty line	0.16 (0.06)	
COLLEGE Fraction of the population within 50 miles of the plant who graduated from college	0.16 (0.04)	
NONTSP Dummy variable =1 for plants located in non-attainment area for TSP	0.23 (0.42)	

a = measured in logs in the regressions; in some analyses measured in 5-year-changes

TABLE 2
BASIC TRI MODELS (N=1500)

DEPVAR	TOTAL AIR EMISSIONS	TOTAL WATER EMISSIONS	CHLOROFORM EMISSIONS	TOTAL TRI EMISSIONS
CONSTANT	11.107	3.872	6.320	11.281
	(22.66)	(4.79)	(6.61)	(29.49)
GREEN VOTE	-0.015	-0.009	-0.024	-0.010
	(-4.80)	(-1.71)	(-3.87)	(-4.12)
PLANT CHARACTERISTICS				
KRAFT	1.136	0.574	0.057	0.957
	(6.84)	(2.09)	(0.18)	(7.39)
PULP CAPACITY	0.226	0.503	0.203	0.229
	(8.25)	(11.08)	(3.79)	(10.71)
PAPER CAPACITY	0.069	-0.269	-0.357	0.007
	(2.97)	(-7.03)	(-7.91)	(0.37)
OLD PLANT	0.130	-0.333	0.854	-0.128
	(1.09)	(-1.70)	(3.68)	(-1.38)
FIRM CHARACTERISTICS				
RETURN ON ASSETS	-0.031	-0.10	0.10	-0.042
	(-1.39)	(-2.69)	(2.28)	(-2.42)
EMPLOYMENT	0.151	0.271	-0.704	0.128
	(2.20)	(2.39)	(-5.26)	(2.39)
PLANT LOCATION AND DEMOGRAPHICS				
BORDER STATE	0.569	0.194	-0.103	0.420
	(4.68)	(0.96)	(-0.44)	(4.43)
POOR	1.677	13.267	2.732	2.550
	(1.24)	(6.02)	(1.04)	(2.42)
COLLEGE	-4.916	3.222	4.484	-2.267
	(-3.56)	(1.41)	(1.66)	(-2.10)
NONTSP	-0.340		1.753	-0.498
	(-2.54)		(6.72)	(-4.78)
PRE-CLUSTER RULE				
y1997	-0.035	0.412	-0.190	0.109
	(-0.15)	(1.06)	(-0.41)	(0.59)
y1998	-0.060	0.803	-0.340	0.084
	(-0.25)	(2.06)	(-0.74)	(0.46)
y1999	-0.067	0.775	-0.698	0.048
	(-0.28)	(1.99)	(-1.52)	(0.26)
y2000	-0.20	0.630	-1.419	-0.027
	(-0.85)	(1.61)	(-3.09)	(-0.15)

TABLE 2 (cont.)

POST-CLUSTER RULE

y2001	-0.424	0.722	-2.578	-0.240
	(-1.78)	(1.83)	(-5.53)	(-1.29)
y2002	-0.464	0.815	-2.835	-0.275
	(-1.96)	(2.08)	(-6.13)	(-1.49)
y2003	-0.502	0.996	-2.982	-0.303
	(-2.12)	(2.54)	(-6.46)	(-1.64)
y2004	-0.419	1.103	-3.139	-0.223
	(-1.77)	(2.82)	(-6.80)	(-1.21)
y2005	-0.488	1.015	-3.287	-0.280
	(-2.06)	(2.59)	(-7.12)	(-1.52)
R^2	0.387	0.327	0.203	0.452
F-TEST I	0.21	1.43	2.95	0.19
F-TEST II	0.05	0.33	0.72	0.06
F-TEST III	0.12	1.35	16.89	1.65

NOTES:
(t-statistics in parentheses)
All models include a dummy variable MISSFIRM=1 for firms with missing Compustat data.
F-TEST I tests for the equality of y1996-y2000
F-TEST II tests for the equality of y2001-y2005
F-TEST III tests for the equality of y1996-y2005

TABLE 3
EXENDED TRI MODELS (N=1500)

DEPVAR	TOTAL AIR EMISSIONS	TOTAL WATER EMISSIONS	CHLOROFORM EMISSIONS	TOTAL TRI EMISSIONS
CONSTANT	10.194 (21.15)	3.305 (4.08)	5.198 (5.53)	10.536 (28.16)
MACT	1.585 (8.71)		-0.632 (-1.61)	1.334 (8.56)
EFFECTIVE MACT	0.365 (1.68)		-0.596 (-1.27)	0.350 (1.87)
BAT		1.192 (4.41)	3.823 (11.30)	-0.016 (-0.12)
EFFECTIVE BAT		-0.327 (-1.02)	-3.390 (-8.42)	-0.097 (-0.60)
GREEN VOTE	-0.009 (-2.83)	-0.008 (-1.47)	-0.024 (-4.08)	-0.005 (-1.97)
PLANT CHARACTERISTICS				
KRAFT	0.754 (4.67)	0.50 (1.83)	0.221 (0.70)	0.640 (5.11)
PULP CAPACITY	0.109 (3.89)	0.429 (9.07)	0.118 (2.14)	0.134 (6.09)
PAPER CAPACITY	0.087 (3.95)	-0.234 (-6.04)	-0.310 (-7.07)	0.020 (1.12)
OLD PLANT	0.001 (0.01)	-0.391 (-2.00)	0.805 (3.63)	-0.235 (-2.66)
FIRM CHARACTERISTICS				
RETURN ON ASSETS	-0.049 (-2.29)	-0.104 (-2.84)	0.091 (2.18)	-0.058 (-3.48)
EMPLOYMENT	0.079 (1.20)	0.260 (2.31)	-0.721 (-5.63)	0.066 (1.29)
PLANT LOCATION AND DEMOGRAPHICS				
BORDER PLANT	0.812 (6.91)	0.340 (1.69)	0.016 (0.07)	0.616 (6.74)
POOR	3.262 (2.52)	14.109 (6.44)	2.817 (1.12)	3.832 (3.81)
COLLEGE	-3.826 (-2.90)	3.614 (1.59)	4.543 (1.77)	-1.369 (-1.34)
NONTSP	-0.239 (-1.87)		1.536 (6.15)	-0.410 (-4.13)

TABLE 3 (cont.)

PRE-CLUSTER RULE				
y1997	-0.076	0.403	-0.199	0.074
	(-0.34)	(1.04)	(-0.46)	(0.43)
y1998	-0.144	0.776	-0.201	0.020
	(-0.64)	(2.00)	(-0.46)	(0.12)
y1999	-0.122	0.765	-0.422	0.013
	(-0.54)	(1.97)	(-0.96)	(0.07)
y2000	-0.260	0.650	-0.825	-0.058
	(-1.16)	(1.66)	(-1.86)	(-0.33)
POST-CLUSTER RULE				
y2001	-0.774	0.798	-0.922	-0.526
	(-2.82)	(1.94)	(-1.73)	(-2.47)
y2002	-0.798	0.910	-1.017	-0.543
	(-2.93)	(2.21)	(-1.91)	(-2.57)
y2003	-0.831	1.092	-1.162	-0.567
	(-3.05)	(2.65)	(-2.19)	(-2.68)
y2004	-0.752	1.198	-1.319	-0.490
	(-2.76)	(2.91)	(-2.48)	(-2.32)
y2005	-0.818	1.110	-1.467	-0.544
	(-3.00)	(2.70)	(-2.76)	(-2.57)
R^2	0.443	0.339	0.28	0.509

NOTES: see Table 2

TABLE 4
TRI MODELS IN 5-YEAR-CHANGE FORM (N=750)

DEPVAR	TOTAL AIR EMISSIONS	TOTAL WATER EMISSIONS	CHLOROFORM EMISSIONS	TOTAL TRI EMISSIONS
CONSTANT	-1.933	0.760	-2.367	-1.693
	(-3.71)	(0.94)	(-1.70)	(-3.91)
EFFECTIVE MACT	0.376		1.086	0.213
	(2.29)		(2.24)	(1.42)
EFFECTIVE BAT		-0.353	-4.510	-0.040
		(-1.74)	(-11.94)	(-0.34)
GREEN VOTE	0.012	0.001	0.011	0.010
	(3.81)	(0.14)	(1.33)	(3.84)
PLANT CHARACTERISTICS				
KRAFT	-0.249	-0.429	0.082	-0.168
	(-1.37)	(-1.52)	(0.17)	(-1.11)
PULP CAPACITY	0.034	-0.057	-0.216	0.056
	(1.10)	(-1.17)	(-2.54)	(2.13)
PAPER CAPACITY	-0.054	0.038	0.207	-0.059
	(-2.16)	(0.96)	(3.06)	(-2.80)
OLD PLANT	0.375	0.213	-0.551	0.213
	(2.94)	(1.07)	(-1.62)	(2.01)
FIRM CHARACTERISTICS				
RETURN ON ASSETS	-0.121	-0.111	0.176	-0.104
	(-4.03)	(-2.35)	(2.19)	(-4.17)
EMPLOYMENT	0.090	-0.257	0.313	0.083
	(1.24)	(-2.24)	(1.61)	(1.37)
PLANT LOCATION AND DEMOGRAPHICS				
BORDER PLANT	0.420	0.424	0.522	0.291
	(3.21)	(2.06)	(1.49)	(2.66)
POOR	5.467	6.288	-8.029	4.856
	(3.83)	(2.85)	(-2.10)	(4.09)
COLLEGE	-2.799	1.033	2.795	-0.871
	(-1.88)	(0.44)	(0.70)	(-0.70)
NONTSP	-0.664		-1.509	-0.578
	(-4.67)		(-3.95)	(-4.86)
POST-CLUSTER RULE				
y2002	0.083	-0.387	0.339	-0.106
	(0.47)	(-1.39)	(0.72)	(-0.72)
y2003	0.130	-0.314	0.506	-0.059
	(0.73)	(-1.12)	(1.06)	(-0.40)

TABLE 4 (cont)

y2004	0.189 (1.07)	-0.114 (-0.40)	0.616 (1.30)	0.053 (0.36)
y2005	0.256 (1.44)	-0.113 (-0.40)	1.286 (2.71)	0.064 (0.43)
R^2	0.126	0.059	0.275	0.134

NOTES: see Table 2;
5-YEAR-CHANGE calculated as $\log(Y_t) - \log(Y_{t-5})$,
so only post-CR years 2001-2005 are included in the regression.

TABLE 5
CONVENTIONAL AIR/WATER POLLUTION EMISSION MODELS

DEPVAR	**PM10**	**SO_2**	**VOCS**	**BOD**	**TSS**
CONSTANT	4.383 (7.34)	8.059 (10.52)	5.395 (9.45)	8.069 (23.24)	8.192 (21.88)
MACT	0.775 (3.91)	0.202 (0.79)	0.656 (3.46)		
EFFECTIVE MACT	-0.481 (-1.45)	0.132 (0.31)	-0.520 (-1.64)		
BAT				0.176 (1.77)	0.228 (2.12)
EFFECTIVE BAT				0.139 (1.03)	0.098 (0.67)
GREEN VOTE	-0.018 (-4.30)	-0.023 (-4.28)	-0.020 (-5.04)	-0.016 (-6.63)	-0.011 (-4.31)
PLANT CHARACTERISTICS					
KRAFT	0.415 (2.24)	0.582 (2.45)	0.499 (2.82)	-0.246 (-2.19)	-0.254 (-2.09)
PULP CAPACITY	0.211 (6.16)	0.30 (6.80)	0.065 (1.98)	0.204 (10.71)	0.227 (11.08)
PAPER CAPACITY	-0.071 (-2.52)	0.006 (0.16)	0.016 (0.59)	-0.099 (-6.05)	-0.110 (-6.27)
OLD PLANT	0.114 (0.81)	0.540 (3.00)	-0.032 (-0.24)	0.076 (0.91)	-0.038 (-0.42)
FIRM CHARACTERISTICS					
RETURN ON ASSETS	-0.001 (-0.04)	0.050 (1.71)	0.006 (0.28)	0.007 (0.45)	0.008 (0.44)
EMPLOYMENT	0.097 (1.17)	0.192 (1.80)	0.031 (0.39)	0.148 (2.90)	0.125 (2.28)
PLANT LOCATION AND DEMOGRAPHICS					
BORDER PLANT	0.145 (0.98)	-0.050 (-0.26)	0.151 (1.07)	0.233 (2.65)	0.336 (3.55)
POOR	-0.957 (-0.62)	-12.629 (-6.41)	-1.318 (-0.90)	1.478 (1.62)	1.540 (1.56)
COLLEGE	-0.903 (-0.56)	-10.445 (-5.01)	-0.780 (-0.50)	-4.011 (-3.92)	-3.419 (-3.10)
NONTSP	-0.503 (-3.07)	-0.113 (-0.54)	0.169 (1.08)		

TABLE 5 (cont.)

PRE-CLUSTER RULE					
y1997	0.036	0.10	0.072	0.066	-0.003
	(0.19)	(0.40)	(0.39)	(0.48)	(-0.02)
y1998	0.078	0.108	0.093	0.055	-0.017
	(0.40)	(0.43)	(0.50)	(0.40)	(-0.11)
y1999	0.058	0.029	0.062	-0.003	-0.067
	(0.30)	(0.11)	(0.33)	(-0.02)	(-0.45)
y2000				-0.054	-0.129
				(-0.38)	(-0.85)
POST-CLUSTER RULE					
y2001				-0.103	-0.125
				(-0.69)	(-0.77)
y2002	0.527	-0.189	0.791	-0.148	-0.205
	(1.70)	(-0.47)	(2.67)	(-0.98)	(-1.26)
R^2	0.39	0.319	0.259	0.425	0.384
OBS	599	599	599	749	749

NOTES: see Table 2

TABLE 6
CONVENTIONAL AIR/WATER POLLUTION EMISSION MODELS IN 5-YEAR-CHANGE FORM

DEPVAR	**PM10**	**$S0_2$**	**VOCS**	**BOD**	**TSS**
CONSTANT	-1.384	-2.742	-1.398	-1.170	-1.436
	(-0.95)	(-1.56)	(-0.81)	(-2.33)	(-2.36)
EFFECTIVE MACT	0.051	1.332	0.056		
	(0.11)	(2.40)	(0.10)		
EFFECTIVE BAT				0.161	0.208
				(1.29)	(1.38)
GREEN VOTE	0.010	0.031	0.020	-0.001	-0.002
	(1.07)	(2.76)	(1.83)	(-0.43)	(-0.40)
PLANT CHARACTERISTICS					
KRAFT	-0.032	0.338	-0.109	-0.191	0.077
	(-0.07)	(0.64)	(-0.21)	(-1.10)	(0.36)
PULP CAPACITY	-0.154	-0.176	-0.047	0.032	-0.003
	(-1.90)	(-1.80)	(-0.49)	(1.11)	(-0.08)
PAPER CAPACITY	0.116	0.128	0.033	0.006	0.033
	(1.69)	(1.54)	(0.40)	(0.26)	(1.12)
OLD PLANT	-0.236	-0.159	0.279	0.032	-0.10
	(-0.71)	(-0.40)	(0.70)	(0.25)	(-0.66)
FIRM CHARACTERISTICS					
RETURN ON ASSETS	-0.092	-0.091	0.029	0.013	0.040
	(-1.04)	(-0.85)	(0.27)	(0.39)	(0.96)
EMPLOYMENT	0.074	-0.138	-0.039	0.190	0.212
	(0.38)	(-0.58)	(-0.17)	(2.49)	(2.28)
PLANT LOCATION AND DEMOGRAPHICS					
BORDER PLANT	0.713	0.262	-0.253	0.093	0.287
	(1.94)	(0.59)	(-0.58)	(0.71)	(1.80)
POOR	4.713	6.817	6.809	0.743	0.096
	(1.31)	(1.57)	(1.59)	(0.54)	(0.06)
COLLEGE	2.569	-1.198	0.497	0.867	1.948
	(0.63)	(-0.24)	(0.10)	(0.56)	(1.04)
NONTSP	0.321	-0.597	0.148		
	(0.81)	(-1.24)	(0.31)		
y2002				-0.034	-0.043
				(-0.30)	(-0.31)
R^2	0.139	0.186	0.079	0.083	0.093
OBS	104	104	104	214	214

NOTES: see Table 2, 4

TABLE 7
SEEMINGLY UNRELATED REGRESSION MODELS: TRI
(CORRELATIONS OF RESIDUALS)

PANEL A: LEVELS

	AIR	WATER
WATER	0.1592	
CHLOROFORM	0.1480	0.0492

Breusch-Pagan test of independence: chi2(3) = 74.526, Pr = 0.0000

PANEL B: 5-YEAR-CHANGE FORM

Correlation matrix of residuals:

	AIR	WATER
WATER	0.2246	
CHLOROFORM	0.0075	-0.0263

Breusch-Pagan test of independence: chi2(3) = 38.404, Pr = 0.0000

TABLE 8
CORRELATIONS OF RESIDUALS: LEVELS

	TRI AIR	TRI WATER	CHLOROFORM	PM10	SO_2	VOCS	BOD
TRI WATER	0.1592*						
CHLOROFORM	0.1480*	0.0492					
PM10	0.3378*	0.1277*	0.0199				
SO_2	0.0821*	0.1441*	0.0053	0.4055*			
VOCS	0.3086*	0.0490	0.0956*	0.3128*	0.1520*		
BOD	0.2825*	0.2192*	0.1043*	0.2633*	0.0893	0.2381*	
TSS	0.2533*	0.2293*	0.0010	0.2938*	0.1143*	0.1425*	0.8872*

* = significant at the 5% level or better

TABLE 9
CORRELATIONS OF RESIDUALS: 5-YEAR-CHANGE FORM

	TRI AIR	TRI WATER	CHLOROFORM	PM10	SO_2	VOCS	BOD
TRI WATER	0.2246*						
CHLOROFORM	0.0075	-0.0263					
PM10	0.1352	0.3606*	0.0449				
SO_2	0.2757*	0.3913*	-0.1650	0.3235*			
VOCS	0.1858	0.2020*	0.1389	0.4416*	0.4632*		
BOD	-0.0135	0.0557	0.2396*	0.3231*	0.0244	0.1472	
TSS	-0.0222	0.0016	0.2231*	0.1639	0.0080	-0.0143	0.8785*

* = significant at the 5% level or better