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ANALYSIS

Grandfather regulations, new source bias, and state air toxics regulations

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Abstract

This paper uses plant-level data from the Census of Manufactures and the variation in toxic air pollution regulations across states to measure the effects of laws that are more stringent for new sources of pollution than for existing sources (so-called 'grandfather' regulations). Of particular interest is the resulting 'new source bias' and its effects on capital vintage and investment. Two industries are examined: commercial printing, which has a local product market; and paint manufacturing, which has a more national market. In general, there seem to be no statistically significant differences in capital vintage or investment between plants in states that grandfather new sources of pollution, plants in states that have no air toxics regulations, and plants in states that regulate both new and existing sources. © 1999 Elsevier Science B.V. All rights reserved.

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1. Introduction

While it has long been recognized that regulations exempting existing activities from new or more stringent controls impart a bias against new investment, the empirical significance of this bias has received relatively little attention. Such 'grandfather' rules are prevalent in many forms of social and economic regulation. They are found in occupational licensing, construction codes, consumer product safety laws (Gruenspecht, 1982), and tax reforms (Zodrow, 1992). With the growth of environmental regulation in the last two decades, grandfather clauses have also played an important role in pollution control. Two well-known examples of grandfather rules in environmental regulations are the New Source

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Performance Standards (NSPSs) established by the 1970 Federal Clean Air Act to control pollution from new industrial sources, and the technological requirements imposed on new cars and trucks to control pollution from mobile sources.[1]

The rationale for grandfathering existing sources of pollution has an economic foundation. The cost of retrofitting existing cars or factories to emit less pollution is generally higher than the marginal cost of building new sources with cleaner characteristics (Portney, 1990). In addition, there are good public policy reasons to grandfather existing sources. One such reason involves fairness to owners of existing sources in the face of changing social norms, scientific understanding of pollution, and government standards. Grandfather regulations may also be favored for political reasons: intuition suggests that existing polluters are likely to be less opposed to regulations from which they will be largely exempt. Some have even suggested that existing polluters will actively support grandfather regulations because they act as artificial barriers to entry and result in non-competitive excess profits (Buchanan and Tullock, 1975, Maloney and McCormick, 1982).

Whatever the impetus for grandfather regulations, economic or political, they have economic and environmental implications that are widely recognized, but have been officially ignored by the Environmental Protection Agency (Smith and Basala, 1982; Birdsall and Speyer, 1984; US Environmental Protection Agency, 1986; Portney, 1990). Perhaps the most important implication of grandfather regulations has been labeled 'new source bias', referring to the fact that grandfather rules provide an incentive to maintain existing productive capital in lieu of new investment. If existing capital is more pollution-intensive than new investment would be, even without the regulations, then by slowing the rate of new investment new source bias may temporarily increase pollution emissions above what they would have been absent the regulations.

Existing research on new source bias has focused primarily on the electric utility industry. Stanton (1993) examines capacity utilization in the electric power industry and finds evidence that electric utilities facing the New Source Performance Standards tend to use older plants at higher capacities relative to new plants. Maloney and Brady (1988) find that sulfur dioxide (SO_2) emissions from electric utilities in the ten states with the largest pollution control budgets were 27% higher than in the rest of the nation. Nelson et al. (1993) use a panel of 44 electric utilities from 1969 to 1983 to show that regulation increased capital age by 25%. But because capital age did not appear to have an independent effect on emissions, the net effect of the grandfather regulations on electric utilities was to reduce emissions, even in the short run. These three studies concur that grandfather regulations and new source bias play important roles in the electricity generation industry. However, electric utilities are regulated in so many dimensions that these results are difficult to interpret. As regulated natural monopolies, electric utilities face rate-of-return regulation. If pollution control equipment can be included in utilities' rate bases, then the NSPSs may encourage investment in some cases.

The only other industry to receive attention from economists studying grandfather regulations and new source bias has been automobiles. Gruenspecht (1982) used a simulation of the US automobile industry to estimate the effects of rising corporate average fuel economy (CAFE) standards on the scrappage rates of old cars, a version of new source bias.[2] He found that rising new car prices significantly increased the average age of vehicles being driven. Kleit (1990) used Gruenspecht's estimate of scrappage rates in a more comprehensive simulation of the effects of CAFE regulations to argue that gasoline savings from these regulations come at very high social costs. In contrast, Goldberg (1988) simulates both

[1] These technological requirements include the corporate average fuel economy (CAFE) standards, as well as emissions limits that are met by installing catalytic converters. In both cases, the increasingly stringent standards apply only to new automobiles; used cars are exempt.

[2] The CAFE regulations require automobile manufacturers to meet average fuel-efficiency thresholds across all cars sold in each year.

the demand and supply sides of the market and concludes that CAFE standards have not been offset by increased driving. However, all three papers rely on simulations to generate the counterfactual thought experiment: what would have happened to vehicle ages had automobiles not been subject to grandfather regulations?

Existing research on grandfather regulations and new source bias thus suffers from two limitations. In the case of the automotive industry, which faces national standards, the measurements depend on simulations to predict investment and pollution absent the regulations. In the case of electricity generation, utilities face rate-of-return regulations that complicate their investment timing decisions and may obscure the effects of grandfather regulations. This paper avoids these two limitations by examining plant-level data on two competitive industries in conjunction with state variation in toxic air pollution regulations. It uses these data to examine the empirical support for the theoretical effects of grandfather regulations on capital vintage and investment. Section 2 describes the data to be used. Section 3 discusses the theoretical consequences of grandfather regulations, and Section 4 presents the empirical results.

2. Data

To examine the empirical effects of these different regulations, this paper uses data from the 1987 Census of Manufactures. The choice of 1987 is intentional: a few years earlier, in 1984, only 19 states had air toxics programs in place (State and Territorial Air Pollution Program Administrators, 1989); a few years later, by 1992, almost every state either had an air toxics regulatory program in place or was planning to implement one in the near future (National Air Toxics Information Clearinghouse, 1992). Two different industries are studied here: commercial printing (SIC 275) and paint manufacturing (SIC 2851). They were chosen for their large size, geographic dispersion, and emissions of toxic air pollutants. Commercial printing was chosen for its relatively local product market, while paint manufacturing was chosen for its more national market.

The 1987 Census of Manufactures enumerated 36108 commercial printing establishments, of which 5578 (15%) had 20 or more employees. The industry employed over 550000 workers. New capital expenditures in the printing industry, totaling $2 billion in 1987, have been motivated by technology driven productivity increases. The letterpress process, which in 1960 provided 45% of industry shipments, produced only 9% of the market in 1990 (US Department of Commerce, 1992a). The decline of the letterpress can be attributed largely to its incompatibility with computerized typesetting. Its replacement, lithographic or offset printing, now accounts for 75% of commercial printing in the US. The local nature of this industry is demonstrated by the lack of international trade: the US imports less than 1% of its printed product and exports less than 2%.

Commercial printing is a useful example for this study because of its air toxics compliance costs. The Commerce Department noted in 1992 (US Department of Commerce, 1992b) that

> the cost structure of the US commercial printing industry will be severely tested over the next 5 years by the public's growing environmental concerns. The printing industry's steady movement away from the use of solvents, toxic compounds, hazardous waste materials, and volatile organic compounds is proving more costly than anticipated.

By 1994, this industry was spending $240 million annually on pollution abatement capital and operating costs. Of these expenses, 60% were for air pollution prevention. By comparison, total new capital expenditures for SIC 275 in 1994 were $2.7 billion.

Paint manufacturing, SIC 2851, involves plants primarily concerned with the manufacture of architectural coatings, product coatings, and specialty coatings. The 1987 Census counted 1426 such plants, of which 626 (44%) employed more than 20 workers. New investment for the industry totaled $275 million in 1987. The paint manufacturing industry has been described as being composed of two broad groups: a relatively small number of large multinational diversified companies, and many regional specialized paint companies. Seven percent of US product is shipped abroad, while 2% of US demand is met by imports. Though by themselves these numbers are not strikingly larger than those for commercial printing, they misrepresent the true strength of international competition because so much of this industry produces intermediate products. Over the last few years, large increases in imports of coated products have decreased demand for US product coatings, tightening the competition faced by the industry (US Department of Commerce, 1990).

Like commercial printing, a major current challenge confronting the paint manufacturing industry is compliance with tightening environmental standards. Among the largest problems for paint manufacturers are volatile organic compounds (VOCs), which are both a toxic air pollutant and a precursor to ozone, one of the six criteria air pollutants regulated by the federal Clean Air Act. Reductions in VOC emissions can be obtained through emission control technologies or by using solvent-free or high-density methods in place of existing solvent-based procedures. In 1994 paint manufacturers spent over $123 million on pollution abatement capital and operating costs, of which 26% went toward air pollution prevention (US Department of Commerce, 1994). By comparison, total new capital expenditures for SIC 2851 in 1994 were $280 million.

This paper uses variation in state toxic air pollution regulations to assess empirically the effects of grandfather regulations on capital vintage and investment. Although many federal laws govern the use, labeling, transport, and disposal of toxic substances, states and local authorities have been primarily responsible for the regulation of toxic emissions from industrial sources (Portney, 1990). As a result of this decentralization, different jurisdictions have regulated toxic air pollution in different ways. As of 1987, the year of the census data used, some states did not regulate toxic air emissions at all, some states regulated both new and existing sources of toxic air pollution, and some states grandfathered existing sources. Appendix A provides the details of state regulations in recent years. It contains the results of five annual surveys of state and local air pollution regulatory agencies conducted by the EPA and contained in the National Air Toxics Information Clearinghouse (NATICH) database. Two questions that were asked are of particular interest here:

1. Does the jurisdiction have an air toxics program?
2. Does the program evaluate existing sources as well as new sources?

Because the plant-level data come from the 1987 Census of Manufactures, this project uses the answers to these two questions for the period before 1988. Based on these responses, 26 states (jurisdictions in the case of California) are sorted into those that had no regulations, those that regulated both new and existing sources of pollution, and those that grandfathered existing sources.[3]

3. Theoretical implications of grandfather regulations

The EPA has in the past used a model to calculate emissions reductions from New Source Performance Standards that focuses only on the static emissions reductions from new sources, ignoring all potential unintended consequences (Smith and Basala, 1982; Birdsall and Speyer, 1984; US Environmental Protection Agency, 1986; Portney, 1990). It assumes the change in emissions from any type of source as a result of an NSPS is

$$\Delta E = (e^1 - e^0)\cdot N \tag{1}$$

where ΔE is the change in emissions resulting from the NSPS, e^0 is unregulated emissions per unit of capital, e^1 is allowable emissions per unit from new sources, and N is the amount of new investment in polluting capital. The EPA has assumed, in most cases, that N is unaffected by the NSPS.

[3] A few cases (CA, KY, MI, MT, WY) rely on responses in later years combined with telephone calls to the agencies themselves to make an assessment of the jurisdiction's status before 1988.

Eq. (1) ignores two potentially important effects of environmental regulations: new source bias and market effects. New source bias is due to the disincentive grandfather regulations place on investing in new equipment. Profit maximizing firms will replace existing capital when the present discounted value of doing so exceeds the cost. By reducing the net returns to investing in new capital, relative to maintaining the old equipment, grandfather regulations will encourage firms to delay investment, decreasing N in Eq. (1). In addition to reducing N, new source bias will increase the amount of older capital that is kept in production. A somewhat more complete version of Eq. (1) would be

$$\Delta E = e^1 N^1 - e^0 N^0 + e^0 \cdot (K^1 - K^0) \tag{2}$$

where N^0 is new investment absent the regulation, N^1 is new investment with the regulation, K^0 is existing capital absent the regulation, and K^1 is existing capital with the regulation. It is reasonable to assume that $N^1 < N^0$ and $K^1 > K^0$. The two effects, the decrease in the amount of new investment and the increase in the economic life of older capital, together constitute new source bias.

If new capital is less pollution-intensive than older capital (either because of technological progress, efficiency gains, the physical depreciation of older capital, or the simultaneous imposition of some other grandfather regulation), then the new source bias may cause a grandfather regulation to increase pollution in the short run, relative to the amount of pollution absent the regulation. Let e_N be emissions from new capital, and e_K be emissions from existing capital. Then Eq. (1) would be altered further to[4]

$$\begin{aligned}\Delta E &= (e_N^1 N^1 - e_N^0 N^0) + e_K^0 \cdot (K^1 - K^0) \\ &= (e_N^1 - e_N^0) \cdot N^0 + e_N^1 \cdot (N^1 - N^0) \\ &\quad + e_K^0 \cdot (K^1 - K^0) \\ &= (e_N^1 - e_N^0) \cdot N^0 + (e_K^0 - e_N^1) \cdot \Delta K \\ &\quad + e_N^1 \cdot (\Delta N + \Delta K) \end{aligned} \tag{3}$$

The first term (third line) is equal to the static estimate of ΔE from Eq. (1), and is clearly negative. It is the direct effect of the new requirement on emissions, assuming investment is unchanged.

The second term of Eq. (3) represents the new source bias: the increase in emissions due to the fact that the regulations encourage the use of older, dirtier capital. This positive effect of new source bias on emissions can, in theory, dominate the static effect of grandfather regulations, yielding a short-run net increase in emissions relative to a world without regulations.

The third term of Eq. (3) denotes the market effect, the fact that total industry investment may respond to the regulations.[5] If exactly the same amount of capital is used before and after the regulation (old capital replaces new one-for-one), then $-\Delta N = \Delta K$, and the market effect is zero. If the regulation discourages overall investment, however, then $-\Delta N > \Delta K$. In this case the market effect mitigates the new source bias. For products with national markets, this effect works through the supply side of the market. Firms will, in theory, be less inclined to invest in regions with stringent regulations and will be more likely to invest in those areas with less costly regulations. With less investment there will be less production, and hence less pollution. For products with local markets, the market effect also works through the demand side of the market, as increased compliance costs will drive up product prices and reduce demand. As a result, old capital will be substituted for new capital on a less than one-for-one basis. Whether from the supply or demand sides, this market effect can in theory offset the emissions increases caused by the new source bias.

One objective of this paper is to disentangle the new source bias and market effects. The new source

[4] Eqs. (1)–(3) all assume that emissions are proportional to installed capital. This assumption may be innocuous for relatively homogeneous industries such as printing or paint manufacturing, analyzed below. However, for many large polluting industries (electric utilities, for example) production techniques and emissions ratios vary drastically across firms.

[5] This market effect is essentially a general equilibrium effect. On the demand side, if regulations cause product prices to rise, people will demand less of the product, and so new investment will be lower. On the supply side, if the regulations increase marginal costs, firms will reduce supply and/or exit the industry, again reducing new investment.

Table 1
Predicted effects of pollution regulations on capital age

	Capital age in states with no regulations	Capital age in states regulating both new and old sources	Capital age in grandfather states
New source bias	0	0	+
Market effects	0	+	+
Total effect	0	+	++

bias may be expected to decrease investment and increase capital age in states with grandfather regulations, relative to investment and capital age in states that regulate both new and old sources or neither.[6] At the same time, the market effect may be expected to decrease investment in any state that regulates pollution. Only the total effect is observable empirically. Comparing grandfather states to all other states, it would be impossible to disentangle the new source bias from the overall market effect of the regulations. However, by examining all three types of regulatory environments, it is in principle possible to distinguish the two effects. To the extent that capital age in states regulating new and old sources is different from capital age in states without regulations, all else equal, that difference must be due to a market effect. To the extent that capital age in states with grandfather rules is older than capital age in states regulating both new and old sources, that difference must be due to new source bias. To the extent that capital age in states with grandfather rules is different from capital age in states without regulations, that difference must be due to a combination of the two phenomena. Table 1 summarizes these predictions. The next section presents evidence of each of these hypotheses.

4. Empirical results

The most direct effect of new source bias, in theory, would be on capital vintage, with plants in grandfather states having older capital than plants in either unregulated states or states that regulate both new and old capital, all else being equal. However, there exists no simple measure of capital vintage. One proxy explored here is plant vintage. From the Census Bureau's Longitudinal Research Database, a panel of quinquennial Censuses, it is possible to determine the 5-year period in which each plant first appeared in the Census of Manufactures. These data are displayed in Table 2.

Table 2 indicates that commercial printing plants in grandfather states are on average slightly newer than plants in other states. The share of plants built since 1982 in grandfather states (19%) is higher than the share built since 1982 in states without regulations or in states regulating both new and old sources (17%). The share of plants built before 1962 in grandfather states (30%) is smaller than that for the other two categories (32%). These results are contrary to the intuition behind new source bias. For paint manufacturing, there is also no evidence that plants in grandfather states are any older than plants in other states.

This lack of support for new source bias could be the result of the imprecise nature of the proxy for capital vintage used. First, the 5-year unit of observation may be too large if capital depreciation rates are sufficiently high. If capital becomes obsolete within a short enough time, with or without grandfather regulations, then the date of first quinquennial census appearance will not be sufficiently precise to observe the effect of new source bias. Second, plant vintage may be a poor proxy for capital vintage. Plants that substantially rebuild existing sources of pollution are generally subject to new source standards, and will not be detected by this proxy. It may be that new source

[6] Note that if retrofitting is truly more expensive than the marginal cost of building cleaner new sources, then states regulating both new and old sources may provide incentives favoring new sources over old—the reverse of new source bias. This, of course, depends on the relative strengths of the regulations.

Table 2
Number of plants in 1987 by year of first census appearance

Year of first census appearance	Commercial printing, SIC 275						Paint manufacturing, SIC 2851					
	States with no toxic air regulations		States regulating both new and old sources		States with grandfather regulations		States with no toxic air regulations		States regulating both new and old sources		States with grandfather regulations	
	n	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%
1967	131	32	447	32	277	30	16	52	89	57	63	56
1972	61	15	206	15	126	13	4	13	17	11	17	15
1977	67	16	245	18	164	18	1	03	20	13	6	05
1982	83	20	261	19	195	21	5	16	13	08	8	07
1987	68	17	235	17	173	19	5	16	18	11	18	16

State with no regulations: AK, DE, MD, ME, MN, MO, MT, NH and NM.
States regulating both new and old sources: CA (Bay Area), IA, KY, LA, MS, NJ, NV, OK, PA, RI, SC and VT.
States with grandfather regulations: CA (South Coast), CT, MI, TX and WY.

Table 3
Investment, commercial printing (SIC 275)

Regulatory category	n	Mean	S.D.
Plants in states with no regulations			
(1) Plant age	220	13.4	7.1
(2) Investment 1987 ($000)	220	521.3	972.8
(3) Investment 1983–1987 ($000)	220	4183.5	6469.1
(4) Capital 1987 ($000)	220	4596.7	7025.4
(5) Capital 1982 ($000)	220	413.3	1093.2
(6) Investment/capital 1987 (by plant)	199	0.20	0.59
(7) Investment/capital 1983–1987 (by plant)	172	16.9	25.9
(8) Investment/capital [(2)/(4)]		0.11	
(9) Investment/capital [(3)/(5)]		10.1	
Plants in states regulating both new and old sources			
(1) Plant age	430	13.4	6.9
(2) Investment 1987 ($000)	430	695.8	2473.9
(3) Investment 1983–1987 ($000)	430	4886.3	12416.8
(4) Capital 1987 ($000)	430	5361.3	13617.1
(5) Capital 1982 (S000)	430	475.1	1431.9
(6) Investment/capital 1987 (by plant)	385	0.16	0.30
(7) Investment/capital 1983–1987 (by plant)	333	23.0	92.3
(8) Investment/capital [(2)/(4)]		0.13	
(9) Investment/capital [(3)/(5)]		10.3	
Plants in grandfather states			
(1) Plant age	389	12.5	7.4
(2) Investment 1987 ($000)	389	459.2	1104.3
(3) Investment 1983–1987 ($000)	389	3624.5	7564.1
(4) Capital 1987 ($000)	389	3929.4	7909.6
(5) Capital 1982 ($000)	389	304.9	728.5
(6) Investment/capital 1987 (by plant)	350	0.26	1.37
(7) Investment/capital 1983–1987 (by plant)	295	21.8	56.8
(8) Investment/capital [(2)/(4)]		0.12	
(9) Investment/capital [(3)/(5)]		11.9	

Includes only plants with more than 20 employees. See Table 2 notes for states in each regulatory category.

bias deters firms from rebuilding existing equipment, but not from opening new plants. To attempt to measure the effect of new source bias on such investment, data on the amount of new investment undertaken are presented in Tables 3 and 4.

Tables 3 and 4 display capital data for plants with more than 20 employees in the paint manufacturing and commercial printing industries. The statistic used both as a measure of proportional investment and as an alternative proxy for capital vintage is investment divided by the book value of capital. Two such measures are used: investment in 1987 divided by the book value of capital in 1987, and investment from 1983 through 1987 divided by the book value of capital in 1982. As a measure of investment, the intuition for these variables is clear. Investment is simply normalized by the size of the plant, as measured by the book value of capital.[7] Book value is a rough approximation of the value of the plant's capital stock.

The fact that it does not account for depreciation overstates its value, but this bias is at least partly offset by the fact that it is in nominal terms, which understates its value.

As a proxy for capital vintage, this index is in the spirit of Grey and Shadbegian (1993): the

[7] Similar results were obtained for investment normalized by the number of production workers.

Table 4
Investment, paint manufacturing (SIC 2851)

Regulatory category	*n*	Mean	S.D.
Plants in states with no regulations			
(1) Plant age		15.6	6.9
(2) Investment 1987 ($000)	34	461.1	1034.7
(3) Investment 1983–1987 ($000)	34	3560.5	6639.7
(4) Capital 1987 ($000)	34	4546.9	6696.3
(5) Capital 1982 ($000)	34	986.4	1586.5
(6) Investment/capital 1987 (by plant)	31	0.11	0.15
(7) Investment/capital 1983–1987 (by plant)	27	5.6	8.6
(8) Investment/capital [(2)/(4)]		0.10	
(9) Investment/capital [(3)/(5)]		3.6	
Plants in states regulating both new and old sources			
(1) Plant age	101	15.7	6.3
(2) Investment 1987 ($000)	101	382.2	628.5
(3) Investment 1983–1987 ($000)	101	3394.4	5658.2
(4) Capital 1987 ($000)	101	4298.0	6433.0
(5) Capital 1982 ($000)	101	903.6	1357.2
(6) Investment/capital 1987 (by plant)	93	0.25	1.37
(7) Investment/capital 1983–1987 (by plant)	87	4.0	4.5
(8) Investment/capital [(2)/(4)]		0.09	
(9) Investment/capital [(3)/(5)]		3.8	
Plants in grandfather states			
(1) Plant age ($000)	92	16.0	6.7
(2) Investment 1987 ($000)	92	580.4	1369.9
(3) Investment 1983–1987 ($000)	92	3721.3	6368.3
(4) Capital 1987 ($000)	92	4840.3	8149.2
(5) Capital 1982 ($000)	92	1119.0	2133.1
(6) Investment/capital 1987 (by plant)	86	0.14	0.17
(7) Investment/capital 1983–1987 (by plant)	78	6.1	13.1
(8) Investment/capital [(2)/(4)]		0.12	
(9) Investment/capital [(3)/(5)]		3.3	

Includes only plants with more than 20 employees. See Table 2 notes for states in each regulatory category.

lower ‘investment/book value’ is, the older the capital in the plants is likely to be. For plants that have made no recent investment, this index will have a value of zero. At the other extreme, a plant built in the last year will have a high value for this index. All other plants will have intermediate values, and in general more recent investment will increase the value of the index.

To check the usefulness of this index as a proxy for capital vintage, the age of the plant is approximated as 1987 minus the year of the plant's first census appearance. This understates true plant age, since a plant ‘born’ in 1983 will first appear in 1987, and will thus have an apparent plant age of zero. The correlation between ‘investment 1983–87/capital 1982’ and plant age is -0.12 for commercial printing and -0.22 for paint manufacturing (with observations on 1778 and 378 plants, respectively). Summaries of the plant age variable appear in the first lines of Tables 3 and 4. Plants in grandfather states do not appear to be older, by this measure.

Tables 3 and 4 present two alternative measures of the ‘investment/book value’ index. The first measure considers each plant as an observation. The averages for the plants in each regulatory category are presented in lines (6) and (7) of each section. For example, in Table 3, the average indices are 0.20 and 16.9 for commercial printers in states with no regulations, 0.16 and 23.0 for

Table 5
OLS regression of investment on regulatory dummies

Independent variables	SIC 275, commercial printing	SIC 2851, paint manufacturing
Intercept	4.216* (0.233)	3.673* (0.524)
ln(capital 1982)	0.649* (0.025)	0.627* (0.047)
ln(state econ growth)	5.492* (2.448)	−1.139 (4.553)
ln(plant age)	−0.114 (0.073)	−0.062 (0.154)
Dummy = 1 if state regulates both new and old capital	−0.029 (0.078)	−0.014 (0.140)
Dummy = 1 if grandfather state	0.052 (0.088)	0.071 (0.157)
R-squared	0.4111	0.4292
Observations	1038	246

Dependent variable: ln(investment 1983–1987). See Table 2 notes for states in each regulatory category.
* Significant at 5%. Standard errors are in parentheses.

states regulating both new and old sources of pollution, and 0.26 and 21.8 for states with grandfather regulations. These patterns do not follow those predicted in Table 1, nor are any of the differences statistically significant at 10%. Although there are no obvious outliers in the data used, the distribution of the indices is extremely broad. The problem with using plants as a unit of observation is that many small plants have widely varying values for these indices.

To stabilize this variation, these two indices are examined another way, by dividing the total investment in each regulatory category by the total capital in each category. These numbers are presented in lines (8) and (9) of Tables 3 and 4. As before, however, no clear pattern emerges resembling that predicted in Table 1.

For a local industry such as commercial printing, a primary determinant of investment is likely to be local economic growth. To measure the effect of grandfather regulations on investment, holding local economic growth constant, Table 5 presents a regression of investment on capital, state economic growth, plant age, and regulatory dummies, in logarithmic form. State economic growth is measured as the annual percentage change in non-agricultural employment. Note that the coefficient on growth is significant and positive for commercial printing, but not for paint manufacturing, confirming the local nature of the former industry relative to the latter. The regulatory dummies, however, are not significantly different from zero, indicating that these air toxics regulations have no measurable effect on investment in either of the two industries.

5. Conclusion

There are several reasons why, despite expectations to the contrary, this research has found no evidence of new source bias. For one, it is impossible to measure capital vintage directly. The proxies used (plant vintage and investment) are either rough approximations to capital vintage or are indirectly related to capital vintage.

Second, states are categorized by type of regulation without regard to the stringency of those regulations. It may be that the variance in regulatory stringency is more important than whether or not existing sources are grandfathered. Unfortunately, such variation is extremely difficult to measure. For example, xylene, a toxic chemical used as a solvent in large quantities by both paint manufacturers and commercial printers, faces very different ambient standards across states in the same regulatory category. Among states classified here as regulating both new and old sources, the standard of Rhode Island is that the average ambient concentration cannot exceed 700 $\mu g/m^2$ in any 24-h period, while the maximum in Oklahoma is 43400 $\mu g/m^2$ in 24 h, and the limit in Vermont is 1040 $\mu g/m^2$ averaged over a year (National Air Toxics Information Clearinghouse, 1991). While direct comparisons of the regulations are difficult because of their different averaging times, they clearly exhibit considerable variation.

Third, new source bias may be offset by what has been called 'regulatory tiering', referring to the fact that regulators appear to ration their limited enforcement budgets by focusing more on large sources of pollution than on small sources. If new plants are smaller on average than old plants (plants take time to grow), then regulatory tiering means that although new sources face more stringent statutes, they face less stringent enforcement, and the regulatory tiering may offset the new source bias.

A fourth reason involves the role of regulatory anticipations in firms' investment decisions. As noted above, 1987 is a good year to study interstate differences in grandfather regulations because the variation in state policies is large. If, however, firms anticipated that by the 1990s, most states would develop air toxics programs that do not exclude existing sources, firms may have had less incentive to maintain existing sources of pollution. On the other hand, for states without regulations, in which a grandfather-type regulation is anticipated, one should expect to see increased investment as firms attempt to build grandfathered sources of pollution before the new law takes hold.

A final reason why this study may have failed to identify strong evidence of new source bias is that environmental compliance costs, despite the attention they receive from economists, policymakers, and industry representatives, may not be large enough to affect investment significantly. Other considerations, such as labor costs, market conditions, and technological advances, may dominate new source bias as a determinant of investment. While pollution abatement investment is certainly a large part of total investment for these industries, the variation in pollution abatement capital costs that is due to state regulations may not be large enough to produce empirically observable effects.

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Appendix A. State regulation of toxic air pollution

Jurisdiction	Pre-1988	1988	1990	1991	1992
Alabama	X		G	G	G
Alaska	0		0	B/0	B/0
Arizona	X			0	B/0
Arkansas	X				
CA (SCAQMD)	G	G	G	G	G
CA (BAAQMD)	X	B	B	B	B
Colorado	0/G		0	0	0
Connecticut	G		B	B	B
Delaware	0			Z	Z
Florida	Z/B	B	B/0	B/0	B/0
Georgia					
Idaho		B	B	Z	Z
Illinois	X				

Appendix A. ***(Continued)***

Jurisdiction	Pre-1988	1988	1990	1991	1992
Indiana	Z		0	Z/0	X/0/Z
Iowa	B			B	B
Kansas	0	G/X	G/0	B/0/G	B/0/G
Kentucky	B	X	X	X	X
Louisiana	B		G	G	B
Maine	0		0	Z	Z
Maryland	0	G	B	B	B
Massachusetts					
Michigan		G	G	G	G
Minnesota	0				
Mississippi	B				0
Missouri	0	0	G/0	G/0	G/0
Montana	Z	0	0	0	0
Nebraska		0	B	B	B
Nevada	B				
New Hampshire	0	B	B	B	B
New Jersey	B	B	B	B	B
New Mexico	0			B	B
New York			B	B	B
North Carolina	Z/0	Z	Z/0	B/0	B/0
North Dakota	Z	Z	Z	Z	Z
Ohio	X/B	B	0	B/0/Z	B
Oklahoma	B	B	B	B	B
Oregon	X/Z	B	B	B	B
Pennsylvania	B	0	B/0	B/0	B/0
Rhode Island	B	B	B	B	B
South Carolina	B	G	G	G	G
South Dakota	Z				
Tennessee	Z	B/0	B/0/G	B/0/G	B/0/G
Texas	G		B	B	B
Utah					
Vermont	B	B	B	B	B
Virginia	X	B	B/0	B/0	B/0
Washington	X	B/0	B/G	B/G	B/G
West Virginia					
Wisconsin					B
Wyoming	Z	G	G	G	G

Source: NATICH, various years. 0, no air toxics program; B, regulates both new and existing sources; G, grandfathers existing sources; X, has air toxics program, did not respond to question regarding existing sources; Z, responded that it did not have an air toxics program, but responded positively to question regarding existing sources; · / ·, states with more than one code in a given year have multiple jurisdictions; BAAQMD, Bay Area Air Quality Management District; SCAQMD, South Coast Air Quality Management District.

References

Birdsall, T., Speyer, J., 1984. New source bias in environmental regulation. A memorandum prepared by Putnam, Hayes and Bartlett, Inc. for the Environmental Protection Agency, May 22. EPA, Washington, DC.

Buchanan, J., Tullock, G., 1975. Polluters' profits and political response: direct controls versus taxes. Am. Econ. Rev. 65 (1), 139–147.

Goldberg, P.K., 1988. The effects of the corporate average fuel effficiency standards in the US. J. Ind. Econ. 46 (1), 1–33.

Grey, W.B., Shadbegian, R.J., 1993. Environmental regulation and manufacturing productivity at the plant level. NBER Working Paper No. 4321, April, Cambridge, Massachusetts.

Gruenspecht, H.K., 1982. Differentiated regulations: the case of auto emissions standards. Am. Econ. Rev. 72 (2), 328–331.

Kleit, A.N., 1990. The effect of annual changes in automobile fuel economy standards. J. Regulat. Econ. 2, 151–172.

Maloney, M.T., McCormick, R.E., 1982. A positive theory of environmental quality regulation. J. Law Econ. 25, 99–123.

Maloney, M.T., Brady, G.L., 1988. Capital turnover and marketable pollution rights. J. Law Econ. 31, 203–226.

National Air Toxics Information Clearinghouse, 1991. Database. US Environmental Protection Agency (EPA), US Department of Commerce, National Technical Information Service, Springfield, VA.

National Air Toxics Information Clearinghouse, 1992. Database. US Environmental Protection Agency, US Department of Commerce, National Technical Information Service, Springfield, VA.

Nelson, R., Tietenberg, T., Donihue, M.R., 1993. Differential environmental regulation: effects on electric utility capital turnover and emissions. Rev. Econ. Stat. 75, 368–373.

Portney, P.R. (Ed.), 1990. Public Policies for Environmental Protection. Resources for the Future, Washington, DC.

Smith, V.H., Basala, A.C., 1982. The economic and environmental impacts of new source performance standards (unpublished mimeo).

Stanton, T.J., 1993. Capacity utilization and new source bias: evidence from the US electric power industry. Energy Econ. 15 (1), 57–60.

State and Territorial Air Pollution Program Administrators, 1989. Toxic Air Pollutants: State and Local Strategies—1989. State and Territorial Air Pollution Program Administrators, Washington, DC.

US Department of Commerce, 1990. US Industrial Outlook. Department of Commerce, Washington, DC.

US Department of Commerce, 1992a. US Industrial Outlook. Department of Commerce, Washington, DC.

US Department of Commerce, 1992b. Current Industrial Reports: Pollution Abatement Costs and Expenditures MA200. US Government Printing Offfice, Washington, DC.

US Department of Commerce, 1994. Current Industrial Reports: Pollution Abatement Costs and Expenditures MA200. US Government Printing Offfice, Washington, DC.

US Environmental Protection Agency, 1986. Summary of regulatory analysis for new source performance standards: industrial-commercial-institutional steam generating units of greater than 100 million btu/h heat input. EPA Document # EPA-450/3-86-005, Washington, DC.

Zodrow, G.R., 1992. Grandfather rules and the theory of optimal tax reform. J. Public Econ. 49, 163–190.