Environmental Compliance and Investment Behavior of Capital-intensive Industries

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Abstract

This study extends the existing literature on location choice in two ways. First, in contrast to the traditional location choice literature, which focuses only on the location of new plants and on re-location of production, this paper examines capacity investments in the existing pulp and paper mills as implicit 'stay-put' location decisions. Second, it bridges two strands of literature on investments in capital-intensive industries, one that follows the assumption of continuous capital adjustments and the other, which adheres to the notions of lumpy investments. We use first-differencing for the continuous capital adjustments and limited probability and logit methodologies for lumpy investments to analyze papermakers' 'stay-put' decisions against a number of supply-side factors. The first group of factors hypothesized to influence the investment decision includes variable input costs – prices for materials, labor, energy and land. The second group includes regulatory stringency of state environmental and tax policies. The findings suggest that short-term capacity changes are sensitive only to energy and land prices while larger inflows of investments respond to the fluctuations in the availability of recycled pulp and land prices. Finally, whether we are looking at a continuous flow of investments or its spikes, we find that state environmental stringency has a negative impact on investments, but it is statistically insignificant through all the models and higher taxes do not deter investments in the pulp and paper industry, contrary to the expectations.

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Introduction

The main purpose of this study is to frame the discussion of choice of location in capital-intensive industries in terms of a 'stay-put' investment decisions. Earlier research on new branch plant location decisions for all manufacturing industries in general found limited support that location characteristics had significant impacts on the choice of new plant locations (Carlton 1983, Bartik, 1985).[1] Later studies, however, find that such local characteristics as environmental regulations affect behavior of pollution-intensive industries (Gray and Shadbegian 1993, Henderson 1996, Levinson 1996, Gray 1997, List 2001, List et al. 2004, Gray and Shadbegian 2005b, Condliffe and Morgan 2008). Further, works that narrowly focused on the pulp and paper industry examined the investment decisions of existing plants (Bergman and Johansson 2002, Gray and Shadbegian 1998, 2002, 2003, 2004, Lundmark 2001, Lundmark and Nilsson 2001, and Lundmark 2003). These studies recognize that local and regional factors play a role in a firm's investment planning. Principally, these studies find that wage rates and such agglomeration factors as the size of existing pulp and paper capacity as well as the size of the consumer market are significant determinants of investment flows.

Building on the theory of short-run profit maximization, we articulate two broad hypotheses: (1) increases in regulatory stringency will decrease capacity levels, and (2) decreases in variable input costs will increase capacity levels. We use first-differencing for small capacity changes and linear probability and logit methodologies for large capacity changes to test the two main hypotheses. The findings from this work contribute to the previous literature in two main ways. First, we explicitly reframe the discussion of the choice of location as a 'stay-put'

[1] More specifically, Carlton (1983) found that energy costs, existing concentrations of employment had strong impact on new plant openings; Bartik (1985) showed that differences in unionization across states had major effect on business location, while state taxes did not.

decision, arguing that building a greenfield at a new location for such capital-intensive industries as pulp and paper is prohibitively expensive and induces firms to invest in existing locations. Second, to bridge various strands in the previous literature, this paper empirically tests two alternative theoretical models of capital investment – continuous vs. lumpy capital outlays. More practical implications of this work will inform (1) policy-makers and industry analysts about the state and regulatory characteristics to which traditional manufacturing employers respond most sensitively, and (2) managers, investment analysts and regional planners about those combinations of location-specific factors and regulatory stimuli that attract further investments into capital-intensive industries under profit maximization.

The findings in this paper suggest that the two models of capital adjustments inform different behavioral choices considered by papermakers. When facing increases in variable input costs, specifically energy and land prices, papermakers respond by decreasing levels of investments. In contrast, when considering larger inflows of investments, availability of recycled pulp and land prices become more important determinants in pulp and paper investments. Additionally, whether the 'stay-put' decision is viewed as a continuous flow of investments or its spikes, state environmental stringency has a negative impact on investments, yet it is statistically insignificant through all the models. Finally and contrary to the expectations, higher taxes do not deter either continuous or lumpy investments in the pulp and paper industry.

Literature Review

The Pulp and Paper Industry in Economic Geography Literature

Historically, the U.S. paper industry has located its operations in areas that economized on one or more major inputs (e.g. fiber, water). In one of the earliest studies of papermakers' location choices Lindberg (1953) used a location theoretic framework to analyze transportation costs of a number of Swedish paper and pulp mills for 1830-1939 and found that distances to raw materials matter less than distances for product delivery and/or export. Barr and Fairbairn (1975) conducted interviews with managers in a number of newly established mills in western Canada in the 1960s and concluded that corporate behavior, rather than government incentives, cost and demand conditions, determine success and viability of location choices made by paper companies. Hayter (1978) conducted interviews with corporate executives in the same geographical area and time period as Barr and Fairbairn (1975) and outlined the executives' decision-making model of the choice of location that consisted of: (1) selecting a forest-rich region, (2) identifying a number of sites which provide the least of both input and output shipment costs, and (3) comparing and selecting the sites. The author concluded that at the regional level corporate decision-making is centered around raw material factors.[2] Table 1 summarized of key locational studies.

[Table 1]

In her extensive survey of regional composition and movements of the U.S. papermakers during 1880-1940, Hunter (1955) points out that technological characteristics of papermaking

[2] Hayter (1978) outlines the following specific cost factors: timber accessibility, quality, species mix and tenurial conditions; cost of adequate power, supply of fresh water for processing, suitable waterways for effluent disposal and minimal effect of air pollution on residential areas, and availability of housing or provision for building new housing.

process have played a principal role in directing papermakers' locational choices. Prior to the advent of papermaking technology that relies primarily on woodpulp kraft process, paper companies tended to cluster in most populous and urban Northeastern states where straw, rags, wastepaper, and manila stock were readily available. Introduction of woodpulp technology shifted production towards areas plentiful with wood fiber resources. Hunter (1955), without explicitly saying it, documents the path dependent behavior of the mills during the 'formative' years of the industry or from around 1880 to 1940. According to her analysis, given the high capital costs, the industry had been more reluctant to rapidly relocate its operations in response to the introduction of woodpulp technology and fluctuating stocks of pulpwood which at the time were affected by the booming lumber and housing markets. The two factors had put pressures on pulp and paper mills to relocate first from urban areas abundant with rag and waste input sources to more rural areas plentiful with forest stands to then even more rural areas rich with self-replenishing forest stands. The author depicts the slow process of managerial learning from experience, gradual but persistent growth in overcapacity, and continual acquiescence to produce paper products in less than optimal production sites, all of which are symptomatic to the situation that the U.S. pulp and paper mills face today. Hunter's (1955) analysis of the industry between 1880 and 1940 suggested that such highly capital-intensive industries as pulp and paper are able to respond to locational pressures in no less than 40-50 years and that sunk costs constrain many of the choices available to such firms.[3]

[3] The author documents the dramatically increased scale of production, vertical integration to internalize procurement costs, and higher responsiveness, reflected in firms' restructuring and relocations, to market and geographic cost conditions among producers of more standardized paper-grades, namely newsprint and wrapping papers, which also demonstrated higher growth rates in consumption.

Location Choices and Paper Industry in Literature, Environmental Factors

Few econometric studies exist on locational choices of papermakers. Gray and Shadbegian (1998) studied the impact of environmental regulations across different states on new plant location decisions of the U.S. papermaking companies over 1972-1990. The authors analyzed the location choices by specific types of pulping technologies installed at new mills as well as annual investment spending at existing mills. The authors concluded that mills choosing to locate in states with stricter environmental regulations ended up installing cleaner technology. Additionally, the study found abatement and productive investments tended to be scheduled together and high abatement costs tended to be associated with lower productive capital expenditures.[4]

In their subsequent work, Gray and Shadbegian (2002) focused on the impact of environmental regulations on the pulp and paper firms' decision to re-allocate productive capacity across states. Using Census' Longitudinal Research Database for 1967-2002 at five-year intervals the authors found that, controlling for other state characteristics, firms allocated smaller shares of production to states with stricter regulations. The results also differed by the firm level of environmental compliance – low compliance firms appeared to avoid states with higher regulatory stringency, while high compliance firms deemed unnecessary to do so.

Lundmark (2001) studied the effect of wastepaper availability and its prices on location decisions of paper producers in 16 European countries over 1985-1995. The study tested the

[4] Gray and Shadbegian (1998) specifically note that high abatement costs over the studied period reflected that environmental investment 'crowded out' productive investment and that "…firms shifted investments towards plants facing less stringent abatement requirements," p. 235. The authors also look at the impact of environmental policies on firm productivity, effects of productive vs. pollution abatement capital, choice of technology, co-relationship with plant vintage, firm structure and managerial expertise and spatial effects on plants' environmental performance.

hypothesis that increases in the importance of wastepaper as a raw material for the industry may have contributed to a structural locational shift/movement of paper companies from forest-endowed areas to regions with high levels of aggregate paper consumption and effective paper recycling programs. The author found that local market size and agglomeration effects were significant location determinants of pulp and paper investments, while prices for raw materials were not.

Lundmark and Nilsson (2001) analyzed the effects of recycling rates and investments in paper recovery infrastructure on location choices of newsprint capacity investments. Country-specific newsprint investment project counts were regressed against four cost factors – tonnage of wastepaper recovered, volume of standing forest, electricity price, and wage; two demand factors – per capita GDP and paper consumption; and income tax for 13 Western European countries over 1985-1995. The two raw material factors and energy input prices were found to be significant and with the expected signs indicating that Western European newsprint industry is resource-oriented while wages were found insignificant. Demand variables were also found to be insignificant. The findings suggest that more standardized grades (such as newsprint and wrapping papers) respond differently to changes in cost and market conditions.

Bergman and Johansson (2002) studied the impact of regional cost factors on investment propensities of the pulp and paper companies in 15 European countries over 1988-1997. The authors found that the most important determinants of European pulp and paper firms' decisions to invest in pulp lines and paper machines were wage rates, installed production capacity, price of the final product and the USD/ECU exchange rate.[5]

[5] European Currency Unit.

Lundmark (2003) looked at three continuous investment models for the pulp and paper industry in ten European countries over 1978-1995. His fixed and random effects models of continuous investment flows indicated that wages, wastepaper availability, market size and agglomeration economies have the strongest impact on papermakers' investment decisions, while prices for raw materials exhibited ambiguous effects.[6] The author concluded that the choice of country to invest was related to time-specific effects that stemmed possibly from market cyclicality, introduction of new technologies, and adjustments in competition patterns due to changes in regional and common polices.

Location Choices and Paper Industry in Literature, Agglomeration and Innovative Activities

Agglomeration forces attract productive investments towards already well-established paper-producing regional markets even if technological advancements and/or requirements may call for geographic relocations (Hunter 1955, Lundmark 2001, Bergman and Johansson 2002). Firms tend to enter regional markets through either vertical integration (Ohanian 1994, Melendez 2002) or horizontal expansion via mergers and acquisitions (Pesendorfer 2003). Greater reliance on recycled raw materials and decreased usage of virgin pulp in the 1990s discouraged vertical integration with timber producers and encouraged gradual relocation towards large metropolitan areas with sufficient supply of waste paper (McNutt 2002). Expectations that biotechnology would provide the industry with the next radical technological boost (Laestadius 1998, 2000) lead to the forecasts that industry clusters would shift even further towards large metropolitan

[6] More specifically, Lundmark (2003) found that wages, wastepaper recovery rate, GDP and agglomeration had the expected signs and high statistical significance, while energy and raw material prices exhibited statistically and substantively ambiguous results.

areas with high research capacity. The main limitation of the enumerated location choice studies is the narrow focus on the establishment of new plants or greenfields and, in the case of the EU studies, the use of country-level aggregates.

Pulp and Paper Industry in Industrial Organization Studies

In addition to the above stream of the Economic Geography studies, there are a few Industrial Organization (IO) papers that have analyzed the industry's regional capital investments and market restructuring. Ohanian (1994) used individual mill level data for years 1900 to 1940 to analyze regional patterns of vertical integration. Studying the period of industry relocation from the Northeast and Great Lakes to South and Pacific Coast, the author found that vertical integration of the U.S. pulp and paper industry is consistent with the transactions cost model of consolidation and positively associated with regional concentration, paper-mill capacity, and production of standardized grades of paper. Consistent with Hunter's (1955) observations of slow reactions of industry to changing technology and cost incentives, Ohanian (1994) documented that the model of vertical integration fitted the cohorts of new entrants much better than the cohort of the established mills. Once mills were built, her analysis showed, they were unlikely to alter their integrated status despite changes in the regional market environment. The author also stated that major adjustments to industry trends occurred through entry and exit, not through changes in integrated status.

Extending Ohanian's (1994) work to cover 1975-1995, Melendez (2002) expanded the definition of vertical integration to include pulp and paper mills that belonged to multi-plant firms and that were located within 350-400 miles away from each other. Melendez's (2002) confirmed Ohanian's (1994) findings that vertical integration was positively associated with mill size, measured in daily capacity, and production of newsprint, or standardized paper grades. In contrast to Ohanian's (1994) results, Melendez (2002) found that the measures of regional concentration were negatively associated with vertical integration. At the same time, lagged concentration measures gave positive and significant results, signaling that vertical integration, as a response to increasing market concentration (or decreasing number of buyers and sellers in the market) during the studied period was not instantaneous.[7] Melendez suggested that the difference in the effects of concentration between these and Ohanian's (1994) findings stemmed from the difference in periods studied.[8]

Documenting the effect of the horizontal merger wave on the welfare of paper and paperboard companies during 1972-1992, Pesendorfer (2003) found that increased capacity and larger number of merged firms generally reduced marginal costs while having little effect on consumer surplus and increasing producer surplus – findings that were consistent with competitive pricing environment and overall increased profits for merging firms.[9] Additionally, the author documented that over 40% of the total capacity expansions for all years combined were achieved through horizontal acquisitions while only 7.29% are achieved through building new plants. Companies affected by mergers tended to be the largest within the industry – acquiring firms were among top 15% largest producers, while acquired firms among 25% top producers. Other findings included evidence of increased likelihood of merged companies to lose their market share and scrap excess capacity.

[7] Melendez (2002, p. 28) reported that the current period concentration measure was negative and significant while lagged concentration measure was found positive and strongly significant. Such results, the author pointed out, demonstrated that mills responded with a lag to market concentration in terms of making decisions about their integration status.

[8] According to the authors, 1900-1940 marked a period of gradual yet massive relocation of the industry to the Southern and Pacific regions of the country, while the years of 1975-1995 did not observe extensive capital relocations.

[9] According to the author, the merger wave followed 1984 revision of merger guidelines.

Following the works of Lieberman (1987a, 1987b, 1987c), Christensen and Caves (1997) analyzed abandonment of previously announced capacity expansion projects in 11 North-American pulp and paper industry segments for 1978-1991. In their analysis, the authors focused on the determinants of firms' decisions to abandon projects that they have previously announced. Such determinants included attributes of the announced project and of the firm sponsoring it, the amount of resources already committed to it, and the fresh news arriving about the project's expected payout. Having found that likelihood of abandonment increased if, during the same year, there were other competing projects announced, the authors suggested that there was some sort of continual auction within the market. According to the authors, the pulp and paper industry "comfortably fitted" into "a two-stage game, in which suppliers first chose their capacities and then competed in the short run within those capacity constraints."[10] The authors found empirical evidence that companies operating in more competitive paper market segments and with few or no financial commitment to the announced projects were more likely to abandon those projects. Further, firms operating in less competitive paper grades were less likely to abandon previously announced capacity expansions and were more likely to complete when similar projects were announced by other/rivaling firms.

To summarize, this brief literature review depicts an old highly capital-intensive industry which has been reluctant to carry out quick adjustments to changes in regional markets (Hunter 1955). Proximity to forest stands, rivers, and transportation links (Linberg,1953, Barr and Fairbairn 1974, Hayter 1978) appear to be prerequisites for the initial papermakers' choices of location. However, once the producers are located in those areas, regional fluctuations in prices for raw materials have significant effects only for the producers of standardized paper grades

[10] Christensen and Caves (1997), p.48.

(Lundmark and Nilsson 2001, Lundmark 2003). Wages (Bergman and Johansson 2002) and environmental regulations (Gray and Shadbegian 1998, 2002) are found to be significant determinants of choice of the optimal location for continuous investments. Agglomeration forces attract productive investments towards already well-established paper-producing regional markets even if technological advancements and/or requirements may call for geographic relocations (Hunter 1955, Lundmark 2001, Bergman and Johansson 2002). Firms are expected to enter regional markets through either vertical integration (Ohanian 1994, Melendez 2002) or horizontal expansion via mergers and acquisitions (Pesendorfer 2003). Finally, firms' strategic expansion and investment plans are announced and contested, as in auctions, in industry publications (Christensen and Caves 1997).

Methodology and Hypotheses

Empirical Methodology

The early models of firm locational choices, developed by Carlton (1983) and Bartik (1985), rise from the theory of dual relationships between firms' production, cost and profit functions. Under this framework, the profit maximization conjectures allow one to infer information on the optimal choice of variable and fixed inputs associated with chosen locations. McFadden (1971) proved one-to-one correspondence between given sets of concave production and respective convex profit functions.[11] The dual relationship of the production and profit functions allows one to estimate parameters of an indirect restricted profit function without having to separately specify the corresponding production function. Under the assumptions of (i)

[11] Following McFadden (1971) and Lau (1971), Lau and Yotopoulos (1972, p.11) observe that "almost all continuous production functions in current use which are concave will give rise to a well-behaved profit function."

a concave production function in variable inputs, (ii) profit maximizing and (ii) firms' output and variable input price-taking, an indirect restricted profit function expresses the maximized profit of a firm as the function of prices of output and variable inputs and the quantities of the fixed factors of production for a given set of technologies and endowment of fixed factors of production. Further, the partial derivative of the indirect profit function with respect to the quasi-fixed factor gives the shadow value of a unit increase in installed capacity. And if the shadow value of installed capacity is greater than the cost of capital (i.e. the user cost of capital which, in general, includes interest, depreciation and obsolescence), then the firm has a profit incentive to increase capacity and invest in additional capacity. Without loss of generality, the profit function can be written as:

(1) $$\pi_{is}^{*} = E(\pi_{is}^{*}),$$

where $E(\pi_{is}^{*})$ is expected profit and u_{is} is a random term with mean 0.

The first step of the empirical analysis is to carry out the first-differenced (FD) estimation by using the logarithm of the changes in the state's annual paper, board, and pulp capacity:

(2) $$\ln C_{st} - \ln C_{st-1} = \sum_{s=1}^{s} \beta(\ln x_{st} - \ln x_{st-1}),$$

where *C* is the state's *s* operating capacity in year *t* measured in thousand short tons and *x* is the vector of state characteristics.

Given installed capital, each firm in time *t* will invest in capacity in state *s* if the expected profit from the investment exceeds the expected profit without the investment, that is $E(\pi_{is}*|given\ investment) > E(\pi_{is}*|without\ investment)$. Yet since we do not observe all of the determining factors, this occurs with some probability. In particular, *Pr*(*invest in state s*) = *Pr*(π_{is}*|*given investment* > π_{is}*|*without investment*)

= *Pr*(*E*(π_{is}*|*given investment*) + $u_{is,investment}$ > E(π_{is}*|*without investment*) + $u_{is,no\ investment}$), or:

$$(3) \qquad \Pr(y_{ist}=1)=\Pr(\pi_{ist1}>\pi_{ist0})=\Pr(u_{ist1}-u_{ist0}>V_{ist1}-V_{ist0}),$$

where π_{ist} is profit π^{*}_{ist} of firm *i* at time *t* in state *s* and the vector of observed characteristics of an investment choice V_{ist} and chosen state *s* at time *t*.

Further, to replicate the earlier studies on the location choice, we estimate the LPM and logit models of the following basic functional form:

$$4) \qquad I_{st}=\beta x_{st}+e_{st},$$

where *I* equals 1 when there is an increase in annual capacity by more than 10 thousand short tons (10K) in a state *s* in year *t* and *x* is the set of state characteristics under consideration. The 10K-tons threshold captures both large investments, associated with the installment of new production lines, and small capital investments, such as those geared towards productive efficiency and environmental compliance.[12] We estimate equation (4) using the ordinary least

[12] Berman and Johanson (2002) defined investment spikes as 50K and 100K tons increases for newly installed papermaking and pulping lines/facilities, respectively. Lundmark (2001) and Lundmark and Nilsson (2001), on the other hand, focused on all capacity increases while discarding investments that resulted in less than 10K tons capacity increases. For the purposes of this analysis, we have estimated models for 10K, 50K, and 100K capacity increases and have chosen the 10K threshold of as the larger capacity increases were far fewer and did not result in substantively or statistically significant estimates.

squares (OLS) and logistic regressions with 2-year lags of the natural logarithm of *x* variables with and without state and year fixed effects.[13]

To carry out the analyses, first, we expand the definition of the dependent variable and use the continuous measure of capacity changes to arrive at the first-differenced estimators as in equation (2). This allows me to utilize all of the information contained in the annual capacity data. Further, to compare the results of the current work with the previous findings, we redefine the dependent variable as in the previous literature – a binary variable with a non-negative value for mills that have been upgraded within the given time frame – and apply it in the limited dependent variable models given in equation (4).

Hypotheses

To test whether environmental regulatory stringency has deterring effect on capacity investments, we follow Gray and Shadbegian (1998, 2002) and include 'non-traditional' costs associated with environmental regulations such as the degree of stringency of local/state environmental regulations. In addition, following the previous literature on the choice of location in the initial cross-industry studies (Carlton, 1983; Bartik, 1985) and in paper industry in particular (Lundmark and Nilsson, 2001; Bergman and Johansson, 2002; Lundmark, 2001, 2003), in the second group of factors hypothesized to influence the choice of location for continuous and lumpy 'stay put' investment decision, we include the 'traditional' factors of production – variable input costs: availability of recycled pulp, labor and energy prices. Given

[13] In addition to state-level, we estimate mill-level FD for the continuous investments and LPM and logit models with and without fixed effects for lumpy investments. The mill-level results are reported in Appendix Tables A.3 and A.4 and specific estimates are reviewed in the section on the overall results.

that pulp and paper mills represent the input-oriented sectors of the paper manufacturing industry which produce intermediate goods (as opposed to final goods), we focus on the input cost structure.[14] More specifically, the hypothesized investment and direct and indirect cost factor relationships are, all else constant:

H1: An increase in the level of stringency of environmental state regulations will decrease the probability of continued investments in a given state, and

H2: A decrease in the prices of variable inputs is expected to increase the probability of an investment at a given state.

Consistent with the previous literature, we expect that variable operating costs will have negative impact on the firm/mill profitability and are likely to divert the investments away from the location with high input prices (Carlton 1983, Bartik 1985, Gray and Shadbegian 1998, 2002, Lundmark and Nilsson 2001, Bergman and Johansson 2002, Lundmark 2001, 2003). Availability of recycled pulp will attract capital investments (Gray and Shadbegian 1998, 2002, Lundmark and Nilsson 2001, Bergman and Johansson 2002, Lundmark 2001, 2003). Tax and environmental policies, on the other hand, impose indirect production costs and higher taxes and more frequent environmental monitoring and enforcement actions will divert the infusion of productive capital (Carlton 1983, Bartik 1985, Gray 1997, Gray and Shadbegian 1998, 2002).

[14] Material inputs for pulp and paper industry include virgin and recycled pulp and, according to McCarthy and Urmanbetova (2009), comprise about 20% of total short-run variable input costs. In order to proxy virgin pulp availability, we have examined a number of measures from the U.S. Department of Agriculture Forest Service inventory. Specifically, we tried the area of forest land, area of timberland, number of growing-stock trees on forest land, and number of live trees on forest land. However, the estimated coefficients for virgin pulp were statistically and substantively insignificant and were omitted from the final analyses.

Data and Variables

Dependent Variable: Lockwood-Post's Capacity

To measure changes in capital investments, we use the data on productive mill capacity collected from the annual editions of Lockwood-Post's Directory of the Pulp, Paper, and Allied Trades (LW), which is a unique source on historical equipment and production processes registry on all U.S. pulp and paper mills since 1873. The annual editions of LW cover all the U.S. territories providing the list of all headquarters and mills for pulp and paper companies by state and city.[15] For this chapter, annual editions for 1979-2002 were surveyed to collect data on all listed mills, annual capacity and product information, zip codes, availability of pulping facilities on the premises of the mills (to ensure identification of vertically integrated mills), ownership information, and the timing of idling and dismantling of the mills.

In this work, we equate the choice of location with the choice to invest additional capital in an existing/operating production site. Traditional economic geography studies examine the choice of location for new branch plants (greenfields), or plant entries (Carlton 1983, Bartik 1985). The rationale for such definition of the dependent variable is that firms choose to build new plants in areas that managers view as 'geographic profit centers.' In addition, works that study the effects of policy variables, such as environmental regulations (Gray and Shadbegian 1993, Henderson 1996, Levinson 1996, Gray 1997, List 2001, List et al. 2004, Gray and

[15] Specifically, each mill is listed with its site or local facility name, parent company and owner (if either are different from the site or local facility name), street address and zip code, mill phone number and indication of the neighboring transport link used by the mill (railroad or highway), and names and job titles of the management team, and the total number of the employees. In addition, more technical and in-depth details are provided on itemized equipment for the following production facilities: wood-handling and preparation, pulp mill, paper mill, steam and power generation, water treatment and effluent treatment. Each mill entry is closed with the list of products, their associated product capacities, and year of establishment (distinguished separately for pulp and paper mills).

Shadbegian 2005, Condliffe and Morgan 2008), argue that many of the environmental requirements are not imposed on older plants ('grandfathering' rules), hence environmental costs are not appropriately allocated among older establishments.

A number of reviewed works focusing on the pulp and paper industry re-define the choice of location as the choice of optimal location for both continuous and new investments (Bergman and Johansson 2002, Gray and Shadbegian 1998, 2002, Lundmark 2001, Lundmark and Nilsson 2001, Lundmark 2003).[16] There is an intuitive reasoning for such definition of the location choice measure. Given the high capital intensity of the industry as well as the number of locational production requirements (closeness to forest stands, running water, and transportation networks), it is reasonable to suggest that papermakers' choices of manufacturing sites is limited by financial and resource prerequisites. Thus, the decision to upgrade existing equipment, whether to increase existing productive capacity, or expand into new product lines, or to comply with the environmental regulations, at any one given site is indicative of the managers' perception that the selected site has superior production characteristics when compared to other sites.[17] Hence, choosing to invest in an existing location becomes a decision to 'stay put' as opposed to try to relocate. And in a sense, the high capital investment is not only a barrier to greenfield by other firms, it is also a barrier to its own greenfield decisions.

[16] Lieberman (1987a, 1987b, 1987c) studies the effect of both new plant entries as well as incremental capital adjustments made by incumbents on the market structure and barriers to entry for the chemical industries.

[17] By similar logic, the decision not to invest into an existing plant may signal the managerial decision to divest the operation with a subsequent exit from the market.

Explanatory Variables

To test H1 on whether environmental stringency has impact on pulp and paper capital investments by increasing abatement, thereby total, costs, we supplement the plant-level LW capacity estimates with the EPA's facility-level Enforcement and Compliance History Online (ECHO) records. The ECHO data base includes information on facility characteristics, its environmental permits and compliance history. The EPA data collections do not report any capacity or production- and/or technology-related information, but we match facility-level compliance with LW production data and obtain mill- and state-level measures of environmental stringency and noncompliance. Environmental stringency is measured by the total number of regulatory monitoring and enforcement actions in air and water pollution media, and mill noncompliance by the number of non-compliant quarters, respectively, and both variables are scaled by state capacity.[18] Unlike other studies that use statewide and all-industry measures of environmental stringency, we match the mill level capacity with the EPA's ECHO data to calculate the total number of inspections and enforcements specific to the mills in the sample.[19] This allows me to use a direct measure of environmental regulatory stringency faced by the pulp and paper mills in the sample. Gray (1997) and Gray and Shadbegian (1998, 2002) found that air and water regulations, as measures of environmental stringency, had negative (yet statistically insignificant) impact on the choice of location and paper-making technology.

The hypotheses under H2 include the following state price and other state control variables: real hourly wages, real electricity prices, availability of wood and waste, tax index for

[18] Air and water inspections and enforcements were collected from the Air Facility System (AFS) and National Pollutant Discharge Elimination System (NPDES), respectively.
[19] In addition to facility-specific air and water inspections, Gray (1997) and Gray and Shadbegian (2002) include Green Policies Index, state environmental spending, and manufacturing pollution abatement costs, adjusted for industry mix.

paper manufacturing and land prices. Previous studies found input costs – wages, energy, materials, and land prices – to negatively impact location and investment decisions in pulp and paper and other industries (Carlton 1983, Bartik 1985, Levinson 1996, Gray 1997, Gray and Shadbegian 1998, 2002, Lundmark and Nilsson 2001, Bergman and Johansson 2002, Condliffe and Morgan 2008, Lundmark 2001, 2003, Bergman and Johansson 2002).[20] As in these studies, we propose that increases in production input prices will increase variable costs, thereby making the location as less desirable for continued investments. In addition to the input price variables, Bartik (1985), Levinson (1996), Gray (1997), and Gray and Shadbegian (2002) found corporate and/or property taxes to have a negative impact on the plant location decision. Similar to the impact of input costs, increased tax rates are likely to deter further increases in investments into productive capacity. For measures of the above variables, we obtain wages from the BEA's Annual Personal Income Employment, energy prices and availability of recycled pulp data from the Energy Information Administration (EIA), land prices from the National Agricultural Statistics Service (NASS) of the U.S. Department of Agriculture, and annual state tax index on production for paper and allied industries from the BEA's Regional Economic Accounts.[21] Tables 2 and 3 present descriptive statistics for all the variables involved in this analysis.[22]

[Tables 2, 3]

[20] Table A.1 in Appendix A lists signs and statistical significance of explanatory variables included in the previous works relevant to this work.

[21] The hourly wage was estimated by dividing the total annual paper manufacturing compensation by the sector employment and then by the total number of work hours in 350 working days. All other variables included in the analysis did not require additional calculations, except for either converting into real 1990 dollars or to the base of 1990 in the case of the tax index.

[22] In addition, Tables A.2-A.3 in Appendix A present correlation matrices for the continuous and discrete investment models.

Results

First-differenced Results

Table 4 presents the state-level first-differencing results for the one-year change in capacity with environmental and input price variables. Model we includes both environmental variables – stringency and noncompliance. No input prices are significant except energy, which has the expected sign. Environmental stringency and noncompliance have expected signs, yet both are statistically insignificant. R-squared explains only 3% of the variation in the dependent variable. Heteroskedasticity-robust standard errors are reported in parentheses and the White (1980) test statistic fails to reject the null hypothesis of no heteroskedasticity. The calculated F-value rejects the null of joint insignificance of all the variables at the 5%-level. The Durbin-Watson test statistic fails to reject the null hypothesis that errors are serially uncorrelated.[23]

[Table 4]

Changes in state environmental stringency, measured by the natural logarithm of facility actions reported in ECHO, have a statistically insignificant negative effect on the changes in the level of state capacity. The 10% increase in the number of facility actions decreases state capacity by 0.04%. Similarly, environmental noncompliance has positive yet substantively and statistically insignificant effect. Given these results, the first hypothesis (H1) of environmental stringency having a negative impact on the continuous capital adjustments can be rejected.

With respect to the second hypothesis (H2) within the framework of the continuous capital adjustments, wages and state taxes have the ‘wrong’ sign -- both are expected to be negatively related to the changes in the state paper capacity, yet have a positive sign. In addition,

[23] Durbin-Watson statistic is 2.08, F-value is 2.93 and the White heteroskedasticity Lagrange Multiplier (LM) value is 20.6 with p-value of 0.98.

taxes are statistically significant at 10% level. And in terms of marginal effects, all else constant, a 10% increase in taxes increases state annual capacity by 0.87%.

In contrast to wages and taxes, energy, land prices and availability of recycled pulp have the expected sighs and energy and land prices are statistically significant at 1% and 5% levels, respectively. In terms of marginal effects, a 10% increase in state energy prices decreases state pulp and paper capacity by 0.82%, and a 10% increase in land prices decreases state pulp and paper capacity by 0.02%, all else the same. Finally, the availability of recycled pulp, approximated by changes in wood and waste consumption in the industrial sector, is positively related to the changes in the state paper capacity. A 10% increase in the availability of recycled pulp increases paper capacity by 0.06%, but is statistically insignificant.

LPM Results

To replicate the results from some of the previous studies, we also ran the linear probability models (LPM) with and without the fixed effects (Table 5) as well as the logit models with and without the fixed effects (Table 6). The dependent variable in these two sets of models is defined as 1 if there is at least a 10K-ton increase in state capacity and 0 if there are no, smaller than 10K tons or negative changes. Table 5 presents the state-level LPM results for the same model reported in Table 4. Column I of Table 5 reports LPM estimates with heteroskedasticity-consistent standard errors, and Column II presents the same model but with state and year fixed effects (FE).[24]

[24] In the LPM and logit models, 'FE' refers to 2-way (year and state) fixed effects.

The LPM results differ substantially from the results of the first-differenced model. Environmental stringency and noncompliance are highly statistically significant in Model I with no FE and have negative impact on the probability of capacity investments, yet both variables become statistically insignificant when FE are included and environmental noncompliance changes its sign from negative to positive (Table 5, Model II). Further, wages have now the expected negative sign and are significant at the 5% level in the FE model. Energy prices are still negatively related to the capacity investments in the estimation with the FE (Table 5, Model II), but are statistically insignificant, and they are positive and statistically insignificant in the model with no FE (Table 5, Model I). Availability of recycled pulp, measured by the industrial wood and waste consumption, is highly significant (at 1% level) in both models, but paradoxically changes sign from positive to negative when going from the LPM with no FE to the LPM with FE. Similarly, taxes are positively associated with the 10K tons increases in state capacity in the model with no FE and are statistically significant at 1% level, but change sign and become in significant in Model II (Table 5). Likewise, land prices change sign from positive to negative when FE are included, and in both cases they are statistically insignificant. Finally, the fit statistics for both models suggest that they are only marginally better than the first-differenced model. R-squared explains 11% of variation in the dependent variable in Model I and 36% in Model II and F-values associated with all four models fail to reject the null of joint insignificance of all the variables in the models at 1% critical value (Table 5).

[Table 5]

Logit Results

Logit results, reported in Tables 6 and 7, are similar to the LPM results in Table 5. As in the LPM results, parameter estimates for the environmental variables are negative and statistically significant for logit, yet, as is the case with the LPM, the statistical significance of the environmental variables dissipates when fixed effects are included. In general, both environmental stringency and noncompliance have negative impact on the probability of 10K capacity investments. Environmental stringency is statistically significant at 5% level, and environmental noncompliance is statistically significant at 1% level (Table 6, Model I). Specifically, for 1% increase in the number of regulatory actions at pulp and paper mills (environmental compliance), decreases the odds of 10 thousand tons capacity investments by a factor of 0.81 and 0.84 in logit models without and with FE, holding all else constant (Table 7, Models I and II). Similarly, under ceteris paribus, 1% increase in the number of noncompliant facility-quarters (environmental noncompliance), decreases the odds of 10K ton capacity investments by a factor of 0.73 and 0.83 (Table 7, Models I and II). As in the LPM models, we find negative but statistically insignificant wage parameter estimates. Energy prices are positively associated with the probability of 10K capacity investments, but are statistically insignificant in the model with no FE (Table 6, Model I).

[Tables 6, 7]

Once the FE are included however, the energy prices become negative yet still statistically insignificant. Taxes are positive and statistically significant at 1% level (Table 6, Model I), but become negative and statistically insignificant in the model with the FE (Table 6, Model II). In 2-way FE logit, the availability of recycled pulp and land prices are statistically significant at 1% level (Table 6, Model II), but both have the unexpected sign – availability of recycled pulp is expected to have impact on 10K capacity increases, while land prices negative. Finally, the goodness-of-fit measure McFadden's (1974) Pseudo R-squared is low.

Robustness Checks

In addition to the state-level models, we also estimated a number of preliminary mill-level models. The results for these estimations are reporting in Appendix A, Tables A.4 and A.5. In the mill-level FD model, environmental noncompliance is found to be negative and statistically significant at 5% level. Energy and land prices, on the other hand, become statistically insignificant. Most importantly, with the exception of environmental stringency, all variables exhibit the expected signs (Table A.4). When examining hypotheses H1 and H2 at the mill level in the lumpy investments context, or in logit estimations with 2-way state/year and mill/year effects, all variables also exhibit the expected signs with the exception of environmental stringency in the model with state and year FE, where it is positive and statistically significant at 5% level. Interestingly, the land variable is negative and statistically significant at 1% level in both state/year and mill/year models (Appendix, Table A.5).

Additionally, to check for potential endogeneity of the environmental stringency and noncompliance we ran the endogeneity tests for all FD, LPM, and logit models at state and mill levels.[25] Both state and mill FD models showed no endogeneity, while the tests within the LPM and logit estimation methods at the state and mill levels showed significant endogeneity – the statistical significance of the individual and joint endogeneity test parameters of environmental stringency and noncompliance strongly rejected the null of exogeneity.[26] To address the issue of

[25] To instrument for state environmental stringency and compliance, we used the 2-year lagged logarithms of the number of landfills in a state and total amount of waste generated. The logic behind these instruments is that dirtier states are likely to have more stringent monitoring and enforcement and the two variables will be correlated with the state's environmental stringency, but not the error term of the unrestricted model.

[26] In order to run the endogeneity tests for the logit models at the mill level, we had to exclude non-compliance as it was correlated with the binary dependent variable and including the 2-way fixed effects in the logit regression resulted in model failing to converge. Once environmental

endogeneity in the next step of this research, we first plan to test the existing instrumental variables (IVs) for their validity using the overidentification test. Also, while controlling for endogeneity is straightforward within the linear panel models, it is more complicated in nonlinear panel data analyses.[27] Finally, all estimations in the future analyses should be done at the mill level.

Discussion

Table 8 presents the signs and significance of all the estimated models. The difference in results and their inconclusive performance from the continuous first-differencing to limited probability and logit models found in this study is not surprising, given the previous literature. Assuming that investments are made in a continuous flow of adjustments to achieve an optimal capital stock, these results suggest that the environmental regulatory variables – environmental stringency and noncompliance – are not as important as input price variables and among the number of the input costs, energy and land have statistical weight while others are statistically insignificant. In addition, taxes have a positive sign and are statistically significant at 10% level.

Unlike most of the surveyed literature on the investments in pulp and paper industry, this study examines the direct impact of disciplinary actions conducted by the environmental regulatory agencies on the investment flows in the pulp and paper sector. Whether we are looking at a continuous flow of investments or its spikes, we find that state environmental stringency has a negative impact on investments, but it is statistically insignificant through all the

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compliance was excluded, however, we failed to reject the null of exogeneity of environmental stringency.

[27] Preliminary examination indicates that the analyses may need to use the Correlated Random Effects (CRE) probit estimation methodology.

models that take into account fixed effects. Firm environmental noncompliance renders even more inconclusive results changing from positive in the continuous and LPM to negative in the logit model, but in all cases with FE, it is statistically insignificant. Using a less direct measure for regulatory stringency, specifically pro-environment Congressional voting, Gray and Shadbegian (2002) found a statistically strong negative impact on papermaking firms' state production shares. Interacting pro-environment Congressional voting with firm compliance, Gray and Shadbegian (2002) conclude that the impact of stringency is concentrated on low-compliance firms.[28] It is possible that interacting my more direct measure of state environmental stringency with firm environmental compliance may change results for one or both of these variables, yet the statistically weak stand-alone effect of the environmental stringency suggests that papermakers' investment decisions are not affected by direct disciplinary actions of environmental regulators.

[Table 8]

Regarding the effects of taxes on pulp and paper investment flows, the continuous and LPM and logit model results without the FE suggest that taxes have a surprisingly positive effect and are statistically significant. However, in the discrete models with state and year FE, taxes have negative and statistically insignificant coefficients. On the surface, this finding is inconclusive and may render little value, however other studies also found inconclusive and unexpected results. Specifically, Carlton (1983) found mixed results, Gray (1997) found negative but only marginally significant results. On the contrary, Bartik (1985) and Gray and Shadbegian (2002) found corporate tax rates to be positive and statistically significant, and Levinson (1996)

[28] This suggests interacting environmental stringency and compliance for this study also to see if results change significantly.

and Lundmark and Nilsson (2001) found positive but statistically weak relationship between taxes and investment projects. However, Gray (1997), Lundmark and Nilsson (2001) and Gray and Shadbegian (2002) focused on pulp and paper industry and their findings that pulp and paper investments are not deterred by higher taxes are confirmed by the results in this work. Overall, the parameter estimates of the policy variables – environmental stringency and noncompliance and taxes – reject the hypothesis H1 that more stringent policies deter pulp and paper continuous and lumpy investments.

The performance of the input price variables in both the continuous and spike-like investment models confirms findings in some but not other studies. Wages appear to be one of the more robust variables in the literature. With the exception of Lundmark and Nilsson (2001), the rest of the studies have found wages to be negatively correlated with the investment and production shifting decisions of the European and U.S. papermakers. My findings suggest that wages have no significant effect on the continuous flow of investments, but a negative and statistically significant effect on the discrete increases in capacity levels (in the case with the LPM 2-way FE model). This finding is consistent with Lundmark (2001, 2003),[29] Bergman and Johansson (2002), and Gray and Shadbegian (2002) and suggests that more expensive labor negatively affects bigger investments in pulp and paper industry.

Availability of recycled pulp, which has been analyzed only in the European studies, has an insignificant positive effect on the continuous investment adjustments and a strong negative effect on the discrete investment increases in the models that control for FE. The strong negative result contradicts the hypothesis that firms are attracted to states with large supplies of recycled paper. Another interpretation of the negative effect is that processing of secondary pulp is

[29] Lundmark (2003) uses a continuous model.

expensive and amount of wood and waste consumed – the measure that is used in this study to proxy for the availability of recycled pulp – is picking up the costs associated with wastepaper processing. In addition, Lundmark and Nilsson's (2001) strong positive relationship of rate of recycling and newsprint investment projects suggests that producers of more standardized grades of paper, such as newsprint, are more interested in the availability of recycled pulp (vs. the consumer product paper producers such as tissue). Hence, in order to determine whether the availability of recycled paper is a determining factor for larger paper investments within specific paper product lines, one needs to differentiate specific pulping and/or papermaking technologies and final products.

Further, we find that land prices are, as expected, negative and statistically significant for the continuous investments in pulp and paper industry. However, they change sign to positive in the discrete models and are highly statistically significant for the logit model with 2-way FE. Gray and Shadbegian (2002) arrived at a similar outcome — they found the effect of land prices to be positive but statistically inconclusive given that this variable's statistical significance changed from insignificant to significant through different models.[30] Finally, scholars specializing in the European paper markets omit land prices altogether, making the findings in this and Gray and Shadbegian's (2002) works distinctive and mutually reinforcing. The unexpected positive and statistically significant result of land prices in the state discrete models suggests that this variable is picking up influences other than of a conventional cost variable. At the mill level however, land prices are negative and statistically significant for logit regressions with 2-way (i) state and year and (ii) mill and year effects (Appendix Table A.4). This suggests

[30] In addition to land prices, Gray and Shadbegian (2002) included state area as a scale control variable. However, when including state FE, land area was dropped from the analysis and the coefficient of land price was still positive and statistically insignificant.

that analyses aggregated to the state level contain other omitted influences and disaggregated analyses are preferred.

Finally, changes in energy prices have the strongest effect on the continuous flow of investments – the results are negative and statistically significant. The negative sign persists through the models, yet its statistical power dissipates when moving from the model of continuous capital adjustments to discrete inflows of investments. This result suggests that energy price is the most important cost variable for the continuous investment adjustments in the pulp and paper industry. Also, the performance of the energy variable from model to model is more consistent than the cumulative findings from the previous literature: Lundmark and Nilsson (2001) and Gray and Shadbegian (2002) found energy prices to be negatively related to the number of newsprint investments and firm production shares, respectively, Lundmark (2001) and Shadbegian (1998) cite positive correlation, and Lundmark (2003) and Bergman and Johansson (2002) report inconclusive results.

To summarize, the H1 hypotheses on the impact of regulatory climates on the choice of pulp and paper investments fail to be accepted for both continuous and lumpy models of investment. Input prices or hypotheses under H2, on the other hand, have mixed results in the two different models of investments. In the continuous or incremental investments adjustments, energy and land prices deter short-term capacity increases. Larger investments are sensitive to change in wages, availability of recycled pulp and land prices. While wages and recycled pulp reflect increases in respective costs, land prices give mixed and inconclusive results at the state level.

Conclusion

The main contribution of this work is to analyze and bridge two strands of literature on investments in the pulp and paper industry, the one that follows the assumption of continuous capital adjustments and the other which adheres to the notions of lumpy investments in capital-intensive industries. The current findings suggest that two models inform different behavioral choices considered by papermakers. When facing increases in variable costs, specifically energy prices, papermakers respond by decreasing levels of investments. However, in day-to-day capital adjustments, regulatory stringency, whether tax or environmental, availability of secondary pulp sources, wages and land prices have little or no effect. In contrast, when considering larger inflows of investments, wages, land prices, and availability of recycled pulp become more important determinants in pulp and paper investments. Finally, whether we are looking at a continuous flow of investments or its spikes, we find that state environmental stringency has a negative impact on investments, but it is statistically insignificant through all the models and higher taxes do not deter investments in the pulp and paper industry, contrary to my expectations.

For future work, we plan to disaggregate the analyses to the mill level and include ten additional years of data extending the study period up to 2013. The preliminary mill-level analyses demonstrate significantly more robust and consistent results across different models and estimations (Appendix Tables A.4 and A.5). Moreover, including political variables as in Gray and Shadbegian (1998, 2002) will inform on the extent to which political pressure has significant impact on the choice of investments in environmentally-sensitive segments of manufacturing such as pulp and paper mills. Similarly, given the previous literature we anticipate that differentiating investments by the type of the pulping and papermaking technology, type of final product, and accounting for local demand factors will provide more comprehensive and theoretically sound findings.

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Tables

Table 1. Previous Literature

Author (Year)	Investigation	Country	Period	Main Findings
Lindberg (1953)	Transportation costs of Swedish paper and pulp mills	Sweden	1830-1939	Distances to raw materials matter less than distances for product delivery/export
Barr and Fairbarn (1974)	Interviews of managers of newly established mills	Canada	1960s	Corporate behavior (versus government incentives) and cost/demand conditions determine location choices
Hayter (1978)	Interviews of corporate executives	Canada	1960s	Corporate decision-making is centered around raw material factors
Hunter (1955)	Descriptive U.S. Census data analysis	U.S.	1880-1940	Sunk costs dictate location choices; papermakers take 40-50 years to respond to locational pressures
Gray and Shadbegian (1998)	Econometric: MNL	U.S.	1972-1990	Mills located in states with stricter environmental regulations install "cleaner" technology
Lundmark (2001)	Econometric: Conditional logit	16 EU countries	1985-1995	Local market size and agglomeration effects are significant location determinants, prices for raw materials are not
Lundmark and Nilsson (2001)	Econometric: Conditional logit	13 Western European countries	1985-1995	More standardized grades (newsprint and wrapping papers) are more sensitive to changes in cost and market conditions
Bergman and Johansson (2002)	Econometric: Poisson ML, CMLE, GMM	15 EU countries	1988-1997	Most important factors for the count of investment projects are wage rates and agglomeration economies, measured as already installed pulp and paper capacity

Gray and Shadbegian (2002)	Econometric: Conditional logit	U.S.	1967-2002	Firms allocate smaller shares of production to states with stricter environmental regulations; low compliance firms avoid states with higher regulatory stringency
Lundmark (2003)	Econometric: OLS, fixed and random effects models	10 EU countries	1978-1995	Wages, wastepaper availability, market size and agglomeration economies have the strongest impact on papermakers' investment decisions; prices for raw materials exhibit ambiguous effects

Table 2. Descriptive Statistics for Variables in the First-differencing Models

Variable (Expected Sign)	Definition	Source	Mean	SD
Dep.Var.: Δ Investment (N/A)	State LW annual capacity in thousand short tons calculated using 350 operating days	FPL, LW, MOL	0.02	0.08
Δ Environmental Stringency (-)	Number of facility actions in state, ECHO, per million short tons of LW capacity	EPA, ECHO	0.04	0.66
Δ Environmental Noncompliance (-)	Number of facility noncompliance quarters in state, NPDES system water, per million short tons of LW capacity	EPA, ECHO	0.06	0.47
Δ Wage (-)	Paper and allied state hourly wage converted into real using regional 1990 CPI for urban workers in average US city	BEA	0.01	0.14
Δ Energy Price (-)	Real price for electricity in the industrial sector in 1990 dollars per million BTU	EIA, SEDS	-0.01	0.06
Δ Recycled Pulp (+)	Wood and waste consumed in the industrial sector at a cost in billion BTU	EIA, SEDS	0.02	0.40
Δ Taxes (-)	Tax index on production and imports less subsidies for paper and allied, 1990 = 100	BEA	0.06	0.07
Δ Land Price (-)	State farm real estate: average value per acre in 1990 dollars	NASS	0.39	1.60

Note: N = 684, all variables are in the log form and explanatory variables are lagged by two years.

Table 3. Descriptive Statistics for the LPM and Logit Models

Variable (Expected Sign)	Definition	Source	Mean	SD
Dep. Var.: Investment (N/A)	1 if more than 10k increase in state LW capacity	FPL, LW, MOL	0.50	0.50
Environmental Stringency (-)	Number of facility actions in state, ECHO, per million short tons of LW capacity	EPA, ECHO	2.33	1.01
Environmental Noncompliance (-)	Number of facility noncompliance quarters in state, NPDES system water, per million short tons of LW capacity	EPA, ECHO	0.33	0.80
Wage (-)	Paper and allied state hourly wage converted into real using regional 1990 CPI for urban workers in average US city	BEA	3.01	0.28
Energy Price (-)	Real price for electricity in the industrial sector in 1990 dollars per million BTU	EIA, SEDS	-1.99	0.31
Recycled Pulp, (+)	Wood and waste consumed in the industrial sector at a cost in billion BTU	EIA, SEDS	9.19	1.56
Taxes, (-)	Tax index on production and imports less subsidies for paper and allied, 1990 = 100	BEA	3.62	1.83
Land Price, (-)	State farm real estate: average value per acre in 1990 dollars	NASS	5.75	2.93
Environmental Stringency, (-)	Number of facility actions in state, ECHO, per million short tons of LW capacity	EPA, ECHO	2.33	1.01

Note: N = 720, all variables are in the log form and explanatory variables are lagged by two years

Table 4. First-differenced Models

Dependent variable: Δ state capacity	Model I
Intercept	0.0124***
	(0.003)
Δ Environmental Stringency	-0.0040
	(0.012)
Δ Environmental Noncompliance	0.0218
	(0.022)
Δ Taxes	0.0869*
	(0.050)
Δ Wage	0.0136
	(0.023)
Δ Energy Prices	-0.0819***
	(0.031)
Δ Recycled Pulp	0.0064
	(0.005)
Δ Land Price	-0.0020**
	(0.001)
Number of Observations	684
R-Square	0.03
Adj R-Sq	0.020

Note: All variables are in the two-year lagged and log form. Heteroskedasticity-consistent standard errors for the OLS estimates were obtained using White (1980) procedure and are reported in brackets. Significance levels are indicated as follows:* significant at the $\alpha = .10$ level, ** significant at the $\alpha = .05$ level, and *** significant at the $\alpha = .01$ level.

Table 5. Linear Probability Models

Dependent variable: 1 if at least 10K capacity increase			
	Model I		Model II
Intercept	0.1161		2.7176***
	(0.229)		(0.747)
Environmental Stringency	-0.0467**		-0.0283
	(0.018)		(0.028)
Environmental Compliance	-0.0760***		0.0332
	(0.024)		(0.029)
Taxes	0.0528***		-0.1075
	(0.014)		(0.089)
Wage	-0.0384		-0.1525**
	(0.069)		(0.074)
Energy Prices	0.0075		-0.0498
	(0.071)		(0.167)
Recycled Pulp	0.0465***		-0.0789***
	(0.015)		(0.030)
Land Price	0.0059		-0.0563
	(0.007)		(0.072)
Number of Observations	720	DFE	658
R-Square	0.11	R-Square	0.36
F Value	11.11	F Value	4.74

Note: All variables are in the two-year lagged and log form. Significance levels are indicated as follows: * significant at the $\alpha = .10$ level, ** significant at the $\alpha = .05$ level, and *** significant at the $\alpha = .01$ level. For the LPM results in Column I and II, Heteroskedasticity-consistent standard errors for the OLS estimates were obtained using White (1980) procedure and are reported in brackets.

Table 6. Logit Models

Dependent variable: 1 if at least 10K state capacity increase	I	II: State/Year FE
Intercept	-1.6898	
	(1.043)	
Environmental Stringency	-0.2103**	-0.1701
	(0.090)	(0.163)
Environmental Noncompliance	-0.3203***	-0.1814
	(0.107)	(0.134)
Taxes	0.2303***	-0.4350
	(0.066)	(0.387)
Wage	-0.1728	-0.6445
	(0.293)	(0.427)
Energy Prices	0.0725	-0.6324
	(0.326)	(0.919)
Recycled Pulp	0.2143***	-0.4255***
	(0.074)	(0.151)
Land Price	0.0254	0.1237***
	(0.031)	(0.048)
N	720	720
-2 Log L	915.3	671.3
Pseudo R-squared	0.083	0.033

Note: All variables are in the two-year lagged and log form. Significance levels are indicated as follows:* significant at the $\alpha = .10$ level, ** significant at the $\alpha = .05$ level, and *** significant at the $\alpha = .01$ level.

Table 7. Odds Ratio Estimates of Logit Models

Explanatory Variables	I	II: State/Year FE
Environmental Stringency	0.810	0.844
Environmental Noncompliance	0.726	0.834
Taxes	1.259	0.647
Wage	0.841	0.525
Energy Prices	1.075	0.531
Recycled Pulp	1.239	0.653
Land Price	1.026	1.132

Table 8. Summary Results

	Continuous	Discrete			
		Without FE		State/Year FE	
	FD	LPM	Logit	LPM	Logit
Environmental Stringency	-	-**	-**	-	-
Environmental Noncompliance	+	-***	-***	+	-
Tax Rates	+*	+***	+***	-	-
Wage	+	-	-	-**	-
Energy Prices	-***	+	+	-	-
Recycled Pulp	+	+***	+***	-***	-***
Land Price	-**	+	+	-	+***

Appendix

Table A.1. Previous Findings

Variables	Levinson (1996)	Gray (1997)	Gray and Shadbegian (1998)	Bergman and Johanson (2002)	Lundmark and Nilsson (2001)	Lundmark (2001)	Gray and Shadbegian (2002)	Lundmark (2003)
Environmental Stringency		-*	-*					
Environmental Non-/Compliance								
Taxes	+, marginally significant	-, marginally significant			+		+*	
Wages	-	-		-/+*	+	-*	-*	-*
Energy	-	+* in some specifications	+	-	-*	+*	-*	-
Land		Land price: -; Area: +*					Land price: +; land area: +*, takes away significance from polit var	
Virgin Pulp			+* for kraft, sulf, mech; - for deink	-*	+*	+		-*

Table A.1. Continued

Variables	Levinson (1996)	Gray (1997)	Gray and Shadbegian (1998)	Bergman and Johanson (2002)	Lundmark and Nilsson (2001)	Lundmark (2001)	Gray and Shadbegian (2002)	Lundmark (2003)
Recycled Pulp				+*	+*	-		Waste paper price: -*; recovery rate +*
Transportation	+*							
Employment	-*	Unions: -*; unemploy ment: +*					Unions: mixed insignificant; unemployment: -	
Income		Mixed			+	+*	+	
Population		-*	-	+*	+	-*	- , mixed	
Agglomeration				Real GDP growth: -*		+*	Paper demand: +*; HHI: -*; state paper production: +*	+*
Education		+*					Mixed insignificant	
Cost of capital			+*	+*				
Exchange rate				+*				
Time trend				-*				
Political pressure	-*	-*	-*				Vote: -*	

Table A.1. Continued

Variables	Levinson (1996)	Gray (1997)	Gray and Shadbegian (1998)	Bergman and Johanson (2002)	Lundmark and Nilsson (2001)	Lundmark (2001)	Gray and Shadbegian (2002)	Lundmark (2003)
Plant age			-*					
Dirty industry		-*					+	
Political party (Democratic)		+*					+ mixed significance	

Note: '-/+' stand for negative and positive signs; '*' for statistical significance at, at least, 10% significance level; and HHI for Herfindahl Index measuring industry concentration. For space reasons did not include Carlton (1993), Bartik (1985), Herderson (1996), List (2001), List et al. (2004), and Condliffe and Morgan (2008).

Table A.2. Correlations for Variables in the First-differencing Models

		1	2	3	4	5	6	7
1	Dep.Var.: Δ Investment	1						
2	Δ Environmental Stringency	-0.03	1					
3	Δ Environmental Noncompliance	0.13	-0.07	1				
4	Δ Taxes	0.08	-0.01	-0.01	1			
5	Δ Wage	0.02	0.00	-0.03	0.05	1		
6	Δ Energy Price	-0.04	-0.05	0.04	-0.10	0.00	1	
7	Δ Recycled Pulp	0.04	-0.09	0.03	0.02	0.01	0.01	1
8	Δ Land Price	-0.04	0.06	-0.03	0.09	0.00	-0.04	-0.03

Table A.3. Correlations for the LPM and Logit Models

		1	2	3	4	5	6	7
1	Dep. Var.: Investment	1						
2	Environmental Stringency	-0.13	1					
3	Environmental Noncompliance	-0.09	0.11	1				
4	Tax Rates	0.25	-0.06	0.24	1			
5	Wage	0.06	-0.10	0.07	0.24	1		
6	Energy Price	-0.02	0.21	0.04	0.22	-0.15	1	
7	Recycled Pulp	0.27	-0.19	-0.04	0.54	0.22	-0.27	1
8	Land Price	0.02	0.30	0.25	0.21	0.17	-0.13	0.05

Table A.4. Mill-level First-differenced Models

Dependent variable: Δ Mill Capacity	I
Intercept	0.0618***
	(0.020)
Δ Environmental Stringency	0.0021
	(0.002)
Δ Environmental Noncompliance	-0.0073**
	(0.003)
Δ Taxes	-0.1735
	(0.184)
Δ Wage	-0.0085
	(0.054)
Δ Energy Prices	-0.0631
	(0.290)
Δ Recycled Pulp	0.0149

Table A.4. Continued

Dependent variable: Δ Mill Capacity	I
	(0.027)
Δ Land Price	-0.3697
	(0.300)
N	2,988
R-Square	0.0008
F Value	0.36

Note: All variables are in the two-year lagged and log form. Heteroskedasticity-consistent standard errors for the OLS estimates were obtained using White (1980) procedure and are reported in brackets. Significance levels are indicated as follows:* significant at the α = .10 level, ** significant at the α = .05 level, and *** significant at the α = .01 level.

Table A.5. Mill-Level Logit Models with State and Year FE

Dependent variable: 1 if at least 10K mill capacity increase	State/Year FE	Mill/Year FE
Environmental Stringency	0.0813**	-0.0098
	(0.033)	(0.035)
Environmental Noncompliance	-0.0912	-0.1850
	(0.114)	(0.120)
Taxes	0.1346	0.0034
	(0.364)	(0.370)
Wage	-0.5711	-0.6408
	(0.394)	(0.392)
Energy Prices	-0.0074	-0.3116
	(0.690)	(0.699)
Recycled Pulp	-0.1984	-0.1864
	(0.149)	(0.150)
Land Price	-1.6646***	-1.6812***
	(0.480)	(0.486)
N	3,190	3,190
-2 Log L	1,997.0	1,475.2
Pseudo R-squared	0.015	0.019

Note: All variables are in the two-year lagged and log form. Significance levels are indicated as follows:* significant at the α = .10 level, ** significant at the α = .05 level, and *** significant at the α = .01 level.