Investment and Environmental Regulation: Evidence on the Role of Cash Flow

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Abstract

We exploit the heterogeneity in pollution permits allocation and the variation in the permits price to identify a new channel by which cap-and-trade programs can affect firm decisions: they may affect investment through the impact of free pollution permits on the firms cash flow. A firm with a permit allocation higher than its emissions will have a higher cash inflow if the price of permits increases, whereas a firm whose emissions are higher than its permit allocation will have a higher cash outflow if the price of permits increases. In the margin they are both paying the same for pollution but the cash flow consequences of the change in permit prices differ. Using data from investor-owned utilities participating in the US SO_2 program, we find that for smaller firms the permit cash flow is positively related to capital expenditures. Small firms with a high permit cash flow invest more than small firms with a lower permit cash flow. This effect is consistent with smaller firms in this industry facing financial constraints.

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1 Introduction

One of the most important aspects of cap-and-trade programs is whether the permit allocation has any effects on firm behavior beyond their impact on pollution decisions. In this paper we argue that in the presence of financial constraints the permit allocation matters. When a firm faces financial constraints, its investment depends, to some extent, on its own resources. Most cap-and-trade programs allocate permits to polluting units for free, and then allow units to trade permit with each other. Therefore, the permit allocation affects the resources available to each firm. For this reason, investment could be related to the permit allocation. In particular, firms with an important discrepancy between their permit endowment and their emissions have a cash flow that is more exposed to changes in permit prices. Firms pay the the same for pollution in the margin, but the cash flow consequences of a change in permit prices varies across firms depending on their permit endowment.

We use the variation in permit prices and heterogeneity in the allocation of permits in the US SO_2 program to identify financial constraints in the electricity sector. The US SO_2 program is a cap-and-trade program that controls sulfur dioxide emissions. It affects fossil-fuels power plants. Every period polluting units get free permits based on a rule that depends on emissions and output in the mid-1980s. Since we use data from 2000 to 2009, that is, more than ten years after the bill introducing the program was approved, it is unlikely that the permit cash flow is correlated in any systematic way with investment opportunities during our sample period.

Moreover, since their introduction, the price of permits has had dramatic variations. In particular, in 2000 the average permit price allowing a polluting unit to emit one ton of SO_2 was \$130,[1] this price reached a peak of \$888 in 2006, and

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[1] This is the EPA auction price.

decreased in the following years reaching just \$38 per permit in 2010. This change in permit prices was mostly a consequence of changes in factors unrelated to the demand for electricity. Particularly, the big jump between 2005 and 2007 was mostly due to regulatory uncertainty after the introduction of a new SO_2 regime for the eastern states. For this reason and in addition to the heterogeneity in the allocation, the permit cash flow constitutes a good instrument to identify the effect of the availability of internal resources on firm investment.

This paper relates to two main lines of literature. First, it relates to the literature that analyzes the relationship between cash flow and investment. Starting with at least Fazzari et al. (1988), a large body of literature studies how, due to asymmetric information and agency problems, a firm's investment may be related to its own resources. This relation between cash flow and investment is a contentious area of research. In a model with quadratic adjustment costs of the capital stock and frictionless access to capital markets (Modigliani and Miller (1958)), investment is explained by marginal Q, and technology and adjustment cost parameters. Cash flow has no role in the explanation of investment if growth opportunities are properly captured by marginal Q. However, if we deviate from the frictionless benchmark of neoclassical investment models, then the borrowing capacity of firms is limited. In this context, the availability of internally-generated funds makes a firm less dependent on capital markets and allows it to invest more if their desired investment is more than what they could be able to fund in financial markets. In their seminal paper Fazzari et al. (1988) take this idea to the data and regress the investment rate on a measure of cash flow and average Q.[2] Their null hypothesis is that under the frictionless benchmark investment should

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[2] Unfortunately marginal Q is not observable, therefore empirical work typically relies on average Q instead. The use of average instead of marginal Q is granted under certain conditions (most importantly constant returns to scale), however in general its use introduces measurement error.

only be a function of Q and deviations from this benchmark will be captured by the coefficient on the cash flow of the firm. Highly constrained firms are able to invest more when they have more internally generated funds.

Fazzari et al. (1988) acknowledge that the use of average Q (Tobin Q) can lead to problems that may explain a significant relation between investment and cash flow even in the frictionless benchmark. For this reason they divide their sample on groups based on their ex-ante likelihood of being constrained and compare investment-cash flow sensitivities across these groups. Their proxy of financial constraints is the dividend payout.[3] Their main finding is that, for all the groups in their sample, investment is positively correlated with cash flow and, and perhaps more importantly, this sensitivity is higher for the groups of firms with lower dividend payout ratios (e.g. more constrained).

Since their publication a number of papers have criticized these results. First, Kaplan and Zingales (1997) argue that theoretically, being more constrained has an indeterminate effect on the sensitivity of investment to cash flow. Moreover, after closer scrutiny of the Fazzari et al. sample they argue that low dividend payout firms do not show much signs of financial constraints (they have high cash balances, high interest coverage, etc.) and these are the ones with the highest sensitivities of investment to cash flow. Second, Tobin Q may be a poor proxy for investment opportunities in which case it is possible for investment and cash flow to be positively correlated even in a frictionless environment. Erickson and Whited (2000) show that once the noise in Tobin Q is accounted for, the explanatory power of cash flow decreases. Alti (2003) shows that, in a frictionless model, the sensitivity of investment to cash flow is higher for low dividend and high growth

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[3] A number of subsequent papers have followed this approach and replicated the Fazzari et al. (1988) approach using other proxies for the financial constraints status of the firm such as age, size, leverage, bond rating, cash holdings, conglomerate membership (Hoshi, et al. (1991)) etc.

firms, because Tobin Q is a noisier measure of investment opportunities for this type of firms. The intuition is that, for a young firm who is still learning about its future profitability, a high cash flow increases a firm's long-term profitability estimate, inducing higher investment. Abel and Eberly (2011) make a similar point and derive a model in which investment is both positively related to Tobin Q and cash flow despite the absence of financial frictions or adjustment costs.

What these papers ultimately argue is that the simple empirical specification of Fazzari et al. (1988) suffers from endogeneity, investment opportunity shocks are likely correlated with cash flow shocks.

Our identification strategy addresses this concern by separating cash flow into an operating and a regulatory components. This later component is arguably more exogenous to investment opportunities during the 2000s as it depends on a rule based on firm behavior in the mid-1980s. We use this component of cash flow to identify the causal impact of internal resources on firm investment.

We follow a relatively long line of research that has exploited this idea. Some noteworthy examples of this approach include Hoshi et al. (1991) study of Japanese Keiretsus; Blanchard et al. (1994) study of firms that win lawsuits; Lamont (1997) study of the response of non oil subsidiaries of oil firms to the oil price decline of 1986; we follow a similar identification strategy as Rauh (2006) who studies firm investment and mandatory contributions to their pension plans. However, unlike Rauh's paper we do not rely on a threshold event for identification. Bakke and Whited (2011) argue that the variable that defines a threshold is often endogenous.

We add to this literature by presenting evidence on the relation between investment and cash flow without resorting to thresholds subject to Bakke and Whited (2011) critique and use an industry that has typically been neglected in previous research. We study a novel "natural experiment" that allows a better identification of the relationship between cash flow and investment: the component of cash flow related to the allocation of pollution permits. This setup is a good experiment for several reasons. Firms are heterogeneous in permit allocation, and the permit price shows variation for reasons exogenous to investment opportunities during the sample period. We have time series variation within each utility and also cross-sectional variation across utilities. Further, this is a relatively homogenous industry and even if the permit cash flow can be related to aggregate conditions, it is not necessarily related to specific information about the firm profitability.

Our paper also relates to the environmental economics literature on the effects of permit allocation on firm behavior and equilibrium. Hahn and Stavins (2010) study the properties under which the market equilibrium is independent of the initial allocation of allowances. Fowley and Perloff (2008) test the independence of firms' permit allocation cycles, and reject the hypothesis that firm-level emissions in equilibrium are independent of the initial permit allocation. Reguant and Ellerman (2008) test whether coal plants in Spain were influences in their operational decisions by their initial allocation of permits. They find no systematic relationship between the initial allocation and production decisions at the unit level.

In our paper, we explore a previously unexplored mechanism through which the permit allocation can have effects on firm decisions. To the best of our knowledge, financial constraints in the context of cap-and-trade program has not been considered yet in academic research. Our analysis has an important policy implication for the design of pollution permit systems. If the firms face financial constraints, the permit allocation can affect capital expenditure. Our analysis has an important policy implication for the design of pollution permit systems. If the firms face financial constraints, the permit allocation can affect capital expenditure.

We construct a measure of permit cash flow that depends on the initial endowment of permits allocated to each firm, the firm emissions and the price of permits. We test whether the permit cash flow is related to firm investment after controlling for investment opportunities, non-permit cash flow and other firm level variables that could influence investment. Our main result is a positive and significant coefficient on the permit cash flow variable. Firms with a higher cash flow from pollution permits invest on average more. Conversely, firms with more emissions than their permit endowment need to buy extra permits to back up their emissions and have less internally generated resources to finance their investment. This effect is stronger for smaller and dirtier firms, consistent with smaller firms in this industry facing financial constraints. We check for the robustness of our results to several potential issues. Since emissions can be endogenous, we instrument them with its lagged values, and obtain similar results. Also, because we may be capturing the aggregate conditions of the economic with the average yearly price of permits, we perform placebo regressions with the US and state level unemployment rate, and with the US and state level GDP growth rate and obtain the same results. Finally, we check for the robustness of our results to the inclusion of controls for the age of the utility, the utility level fuel cost, the listing status of the utility and its parent, and additional growth opportunities proxies (imputed Q). The results remain.

We organize this paper as follows. In section 2, we introduce a simple investment model with financial constraints and environmental regulation in the form of a cap-and trade-program. In section 3, we explain how the US SO_2 program works and introduce the data. In section 4, we present the empirical framework and explain our main test. In section 5, we report and discuss the results. Finally, we conclude in section 6.

2 The Model

Following Adda and Cooper (2003) we present a simple model of investment. We add environmental regulation in the form of a cap-and-trade program to explain how emissions and permits affect the dynamic investment problem. Then, we introduce a financing constraint and analyze its effects on the main variables, particularly its interaction with the environmental regulation in determining optimal investment.

A firm faces a cap-and-trade program, gets permits for free every period denoted by $\bar{e}$ and has to pay for its emissions denoted by e. The price of permits is p^e. The firm produces output $q = F(K)$ that is a function of the capital level K. The price of output is normalized to be equal to 1. We denote with primes future variables. Let δ be the depreciation rate. Let the function $C(K', K)$ be the adjustment costs and let $C^A(\epsilon - e)$ be the abatement cost,[4] that depends on actual emissions e and ϵ. The variable ϵ is the maximum possible emissions without incurring in any kind of abatement. If the firm decides not to abate anything, then $e = \epsilon$ and $C^A(0) = 0$. On the contrary, if the firm abates the maximum possible, then $e = 0$ and the firm pays the maximum abatement cost $C^A(\epsilon)$. The trade-off that the firm faces is paying more on abatement but less on pollution permits, or spending less in pollution permits but more on pollution abatement.

The firm chooses the optimal level of capital for the next period (K'), and emissions e. The cost of an additional unit of capital is p. Let $\mathbf{p} = [p, p^e]$ be the price vector. Then, the problem of the firm is:

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\begin{aligned}
V(K, \mathbf{p}) = \quad & max_{K',e}\{F(K) - p^e(e - \bar{e}) - C^A(\epsilon - e)... \\
& ... - C(K', K) - p(K' - (1 - \delta)K) + \beta E_{\mathbf{p'}/\mathbf{p}} V(K', \mathbf{p'})\}
\end{aligned}
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[4] The cost of reducing pollution.

where $V(K, \mathbf{p})$ is the value function that shows the value of a firm with level of capital K and prices $\mathbf{p}$. The first order condition with respect to e and K' are, respectively:

$$p^e = C_e^A(\epsilon - e)$$

and

$$\beta E_{\mathbf{p}'/\mathbf{p}} V_{K'}(K', \mathbf{p}') = p + C_{K'}(K', K) \tag{1}$$

where subscripts denote derivatives.

The first condition states that the firm chooses emissions such that the marginal cost of abatement equals the price of permits. The second condition says that the optimal capital stock of the firm will be such that the marginal return on capital equals the cost of an additional unit of capital today plus the marginal adjustment cost. The left side of the expression measures the expected marginal gains of more capital or the marginal Q, also denoted by q.

Assuming quadratic cost of adjustment and a profit function proportional to K, marginal Q equals average Q, which is the typical proxy for investment opportunities used in empirical work.

We incorporate the financing friction in reduced form assuming the firm faces the restriction that investment has to be financed by current profits.[5] That is:

$$p(K' - (1 - \delta)K) \leq F(K) - p^e(e - \bar{e}) - C^A(\epsilon - e) - C(K', K)) \tag{2}$$

The term $p^e(e - \bar{e})$ is the discrepancy between what the firms pays for its own emissions and the free permits that it gets every period. If this term is positive then the firm has extra cash and the restriction on investment will be looser. On

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[5] This is a shortcut to modeling the underlying economics that may lead to financing restrictions. Endogeneizing this restriction will require adding more structure to the current problem and considering the information asymmetry between the providers of capital and the agents making investment decisions in the firm.

the other hand, if the firm has more emissions than free permits, then the firm has few resources available to spend on investment. Firms with no financial constraints choose the optimal capital level such that (1) holds. If the firm faces financial constraints and (2) is binding, then firm investment depends upon the permit cash flow they have every period.

3 Institutional Details and Data Description

3.1 Acid Rain Program: Background

The Acid Rain Program, instituted under Title V of the 1990 Clean Air Act Amendments (CAAA), established a pollution permit system to regulate SO_2 emissions in the electricity generation sector. The program affects coal, gas and oil plants, and it has constituted the biggest pollution permit system implemented in the US until now. The government issues a fixed amount of permits every year. It distributes the permits at no cost at the boiler level.[6] Plants can trade permits between each other. At the end of the year, they have to back each ton of SO_2 with a permit. The program started in 1995 and was implemented in two phases. The first, from 1995 to 1999, included only the 263 dirtiest units (110 power plants, "Table A" plants). The second phase began in 2000 and included every generating unit with a capacity higher than 20 Mega Watts (MW), about 2,000 units. Also, in the second phase, the cap was set to 9.5 million tons. In 2010, a new cap was set at 8.95 million tons.

Every year, units get a fixed amount of permits that does not change while the units stay in business. The allocation of permits depends on past output and emissions. Bigger, dirtier units receive more allowances. The rule for allocating permits is as follows:

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[6] A boiler is the device used to heat the input in the power plant.

- From 1995-1999 (first phase), the EPA (Environmental Protection Agency) allocated allowances at an emission rate of 2.5 pounds of SO_2/mmBtu of heat input, multiplied by the unit's baseline mmBtu (the average fuel consumed from 1985 through 1987).
- In the second phase (from 2000), the EPA allocated allowances at an emission rate of 1.2 pounds of SO_2/mmBtu of heat input, multiplied by the unit's baseline.

Every boiler gets permits according to that rule and the plants keep them forever, even if the boiler exits the industry. New plants that began operating after 1995 do not receive any free allowances. Therefore, the amount of permits that a plant receives for free every period does not change with its investment decisions through time.

Plants can reduce their SO_2 emission in several ways. They can invest in flue gas desulfurization units (FGD) called scrubbers, which remove up to 90% of SO_2 emissions. However, these devices are very expensive, and only a few plants have adopted them. Plants also have the choice of using low-sulfur coal instead of high-sulfur coal. However, as transportation costs for coal are high, for a plant that is located near a high-sulfur coal mine, switching to low-sulfur coal is probably more expensive than using high-sulfur coal and pay more for emissions.

The program constitutes a good experiment for our purpose because each firm gets a fixed amount of permits every period that is arguably not related to investment opportunities in the 2000s. We argue this because the permit allocation was decided based on pollution per heat input unit and size in the mid-1980s. We consider that the period of time between the initial allocation (1985-1987) and our period of analysis (2000-2009) is long enough so that new investment opportunities are not necessarily highly correlated with output more than fifteen years earlier.

However, despite the significant time since the design of the allocation rule, we acknowledge that there is still a possible source of correlation between the way permits were initially allocated and investment opportunities. In the initial allocation larger firms received more permits, and past values of output could be correlated with their current values (in the 2000s). If new investment opportunities are correlated with size in the past (larger firms in the past are also larger today and they are more likely to invest) then this could generate an endogeneity problem as firms with more permits may invest more. We include firm fixed effect to partially account for this issue.

The cap-and-trade program also allows for banking. Firms can save current allowances for future use. We do not take into account the amount of banked allowances each firm holds, as they are a firm decision and therefore possibly endogenous; rather we focus on the difference between the exogenous amount of allowances that the firm was initially allocated to each period and their emissions. This is the extra cash that it has because of the regulation. The fact that the firm can sell or bank the permits does not change the fact that it has extra resources.

An electrical utility can have several power plants. We perform our analysis at the utility level, and aggregate the various power plants that can be under the same utility, since we think this is the relevant decision unit for investment purposes.

3.2 Data

The data we use in this paper is from the investor-owned utilities participating in the US SO_2 program. Unfortunately, we have no financial information for the group of independent power producers participating on the SO_2 program so we have to restrict the analysis to the relatively large investor-owned utilities. We expect this sample selection restriction to work against us finding a result for two reasons. The first one is that financial constraints are more associated with smaller firms (Carpenter et al. (1994), Almeida et al. (2004), Beck et al. (2005), Forbes (2007), Hadlock and Pierce (2010)) and the second one is that they are not regulated as most of the bigger electric utilities.

The dataset covers the years 2000 to 2009 when all polluting units were participating in the cap-and-trade program. To assemble the dataset we had to merge and match several sources. We obtained the financial data from Form 1 (Annual Report of Major Electric Utility) of the Federal Energy Regulatory Commission (FERC). We obtain the data on allocation of allowances, emissions, compliance and output from Data and Maps of the U.S. Environmental Protection Agency (EPA), and the data on generating capacity from Form 860 of the Energy Information Administration (EIA). We obtained the data on the type of utility[7], parent company information and NERC region from the EGRID data. We obtained detailed data on type and costs of fuels from Form 423 of the EIA, and data on environmental devices and abatement capital expenditures from Form 767 and Form 923 also of the EIA[8].

Our measure of the pollution permit price is the EPA auction price.[9] Figure 1 shows the pollution permit price evolution over the past decade. In 2000, the price was below \$200 and it reached almost \$900 in 2006. The big jump in 2005 and 2006 was mainly due to regulatory uncertainty caused by the introduction of the Clean Air Interstate Rule that implied further reductions of SO_2 emissions in the eastern US. After its passing, the pollution permit price started to decrease mainly for two factors: first, a fall in gas prices; and second, plants started to install scrubbers[10] to comply with the future requirements of SO_2, which reduced

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[7] Investor Owned Utility, Cooperative, etc

[8] Due to a change in the data collection procedure, there is no environmental investment data available for the years 2006 and 2007.

[9] The CAAA mandates the EPA to hold yearly auctions to help ensure that new units have a public source of allowances to help ensure that new units have a public source of allowances beyond those initially allocated to existing units.

[10] In our sample, more that 70 percent of the FGD units added during our sample period

Figure 1: Permit Prices. This figures shows the evolution of the EPA auction price for the years 2000 to 2009. The CAAA mandates the EPA to hold yearly auctions of allowances to help ensure that new units have a public source of allowances beyond those initially allocated to existing units. The auction is held usually on the last Monday of March.

the expected demand for permits in the future bringing down its current price.[11] The changes in permit price for this reasons allows us to have a source of variation that does not depend on changes in electricity prices. Had this been the case, our permit cash variable could had been correlated with investment opportunities and therefore make the identification of causal effects more complicated. The permit price changes were mainly caused by changes in the regulation of SO_2 and had little to do with demand factors.

To have a measure of how the cash flow of the firms are affected by the free permits, we construct the following variable for each firm:

$$PermitCash = p^e(\bar{e} - e)$$

(scrubbers) were added in 2005.

[11] More information about evolution of prices can be found at http://www.epa.gov/airmarkets/resource/docs/marketassessmnt.pdf.

where p^e is the price of permits, e are the observable emissions of the firm and $\bar{e}$ are the permits that the firm gets.

The data set is an unbalanced panel of 72 electric utilities covered over 10 years between 2000 and 2009. Table 1 shows the summary statistics for the main utility level variables used throughout the paper. The utilities are generally very large firms, the average book value of assets is \$5,860 million, however, they vary widely in size, the smallest utility in our sample is the Indiana-Kentucky Electric Corp. whose total assets averaged about \$300 million during the sample period while the largest one is Pacific Gas and Electric Co. whose total assets averaged more than \$30,000 million during the sample period.

Yearly capital expenditures average \$461 million. This represents 8.1% of beginning of the period total assets. The investment rate ranges from -6.5% to 59.9%. Our main explanatory variable, permit cash flow, has a mean value very close to zero (averages $-0,1\%$). This is not surprising as the total allocation of permits is supposed to equal the total emissions, therefore the aggregate permit cash flow is supposed to be zero. However, our sample utilities have an small shortage of permits relative to their emissions (on average 65,463 tons of permits and 73,157 tons of SO_2 emissions). Nevertheless, while the average is close to zero, the yearly permit cash flow has variation in the sample. It ranges from -7.2% of beginning of the year total assets to a maximum of 1.4% of assets. It is variation in this variable, particularly the time series variation within each utility, what we exploit in our empirical analysis.

Figure 2 shows a graph of the $PermitCash$ variable for each firm and the price of permits over time. When the price of permits is low as, for example, in 2010, the permit cash is similar and small in absolute value for all firms. The dollar value of the discrepancy between emissions and endowment is low. When the price increases, the dispersion in permit cash flow increases. A higher discrepancy

Table 1: Summary statistics

This table presents the summary statistics of the main variables used throughout the paper. The data on Emissions, Allowances, and Output was constructed by aggregating at the utility level the plant level data obtained from the EPA Data and Maps. Financial statements data at the utility level was obtained from the FERC Form 1. *Tobin Q Imputed* corresponds to a proxy of Tobin Q constructed after regressing Tobin Q for electric services firms with publicly traded stock on a set of variables thought to be related to the marginal product of capital (ROA, Sales Growth, Leverage, and Size), and then using those estimated coefficients to impute its value for private firms. Air abatement capital expenditures corresponds to the capital expenditures in abatement to reduce air contamination, the summary statistics for this variable do not include observations from 2006 and 2007 due to lack of data.

Variable	**Mean**	**Std. Dev.**	**Min**	**Max**	**Median**
Emissions (tons)	73,157	94,597	0	636,827	47,016
Output (Gwh)	17,668	16,937	0	103,383	14,151
Allowances (tons)	65,463	71,440	0	603,335	49,396
Total Assets (Million $)	5,860	6,490	164	38,131	3,383
Capital Expenditures (Million $)	461	603	-116	5,373	250
Air Abatement Capital Expenditures (Million $)	37	81	0	600	1.8
Additions of FGD Scrubbers (units)	0.264	1.281	-6	15	0
Investment (rate)	0.081	0.053	-0.065	0.599	0.069
Permit Cash Flow (rate)	-0.001	0.007	-0.072	0.014	0.000
Operating Income (rate)	0.048	0.019	-0.141	0.149	0.050
Tobin Q Imputed	1.134	0.106	0.584	1.551	1.126
N			662		

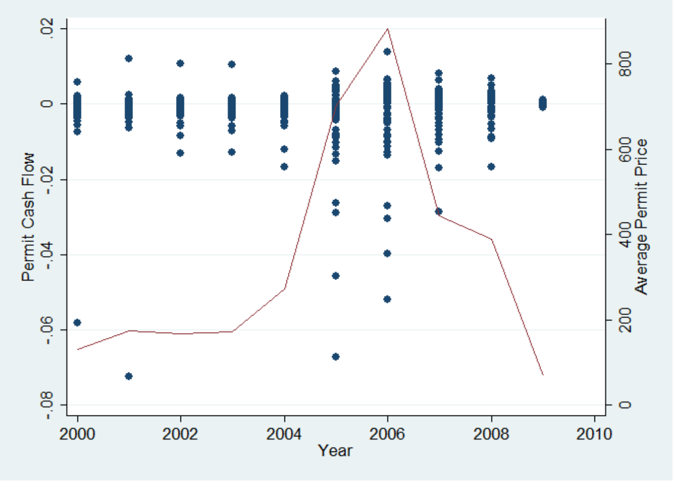

Figure 2: Permit Cash Flow. This figures shows the evolution of the permit cash flow for all utilities (right vertical axis) and the EPA auction permit price (left vertical axis) for the years 2000 to 2009. The permit cash flow for each firm is defined as $p^e(\bar{e} - e)$ where p^e is the price of permits, e are the observable emissions of the firm and $\bar{e}$ are the permits allocated to the firm.

creates more exposure to permit prices. Utilities can spend up to 7% of the value of their assets paying for permits or obtain up to 1.5% of the value of their assets in permit cash.

4 Empirical Analysis

4.1 Econometric Model

To study whether the permit cash flow affects firm's investment decision we use the following empirical model:

$$\frac{Investment_{i,t}}{A_{i,t-1}} = \alpha_i + \alpha_t + \beta_1 \frac{SalesGrowth_{i,t-1}}{A_{i,t-1}} + \beta_2 \frac{PermitCash_{i,t}}{A_{i,t-1}} + \dots$$
$$\beta_3 \frac{OperatingIncome_{i,t-1}}{A_{i,t-1}} + \beta_4 X_{i,t-1} + \epsilon_{i,t}$$

Variables are scaled by total assets $A_{i,t-1}$ at the beginning of the period, in order to normalize them by the same quantity.

The variable α_i represents a firm specific error that is constant through time and α_t represents the coefficients on a full set of year dummies. The firm specific effect captures the average effect of all possible omitted variables whose effect is constant through time, and is not allowed to be correlated to the other explanatory variables (RE) or is allowed to be correlated with the other explanatory variables (FE) depending on the regression specification.

We include a full set of year dummies to control for the business cycle, that is, for variations in investment opportunities common to all the firms on a given year (e.g.: changes in input prices, changes in the aggregate demand for electricity). The inclusion of a full set of year dummies is very important in this setup, as they capture the potential correlation between investment opportunities and permit prices.

To proxy for the investment opportunities specific to each firm the investment literature typically uses either sale growth or Tobin Q. We cannot include Tobin Q in all the regressions because most of the investor-owned utilities in our data do not have publicly traded shares. Therefore, we rely on sales growth as a proxy for investment opportunities. Several papers use this variable to control for investment opportunities (see for example Acharya et al. (2007), Asker et al. (2011), Billet et al. (2007), Whited (2006)). We include the ratio between operating income and total assets. This measure differs from the cash flow proxy used by Fazzari et al. (1988) in that we do not deduct the non-cash deductions from it, we leave this variable in the model as a proxy for both operating cash flow and profitability. We further proxy investment opportunities with an Imputed Tobin Q to check the robustness of our results.

The two components of cash flow in the equation are crucial to understand our empirical approach. As previously mentioned, a vast literature discusses the correlation between firm investment and firm cash flow. However, there is less agreement on the causes for this correlation. Some argue that this correlation is the reflection of financial constraints (Fazzari et al. (1988)), while others argue that even in perfect markets it is possible for investment to be correlated with cash flow (Alti (2003), Abel and Eberly (2011)). One important explanation for this disagreement is the potential information about investment opportunities that may be embedded in cash flow even after controlling for investment opportunities with Tobin Q.

The main novelty in our identification strategy is the disaggregation of cash flow into two components.[12] The first component is the operating cash flow and is the one that could plausibly be more correlated with investment opportunities. The second component of cash flow and the subject of this paper, permit cash flow, is a part of cash flow that is more exogenous to investment opportunities. The allocation of pollution permits generates heterogeneity in this cash flow across firms and is arguably less correlated (if any) to current investment opportunities because it depends on a rule that depends on the firm conditions more than fifteen years before the start of our sample period. Differences in the investment behavior of two firms equal in all dimensions other than permit allocation will present cleaner evidence on the role of cash flow as a determinant of investment.

The empirical proxies of these two components of cash flow are the following. $OperatingIncome$, which we define as:

$$(Sales - OperatingCosts - GainsAllowances + LossesAllowances)$$

controls for the operating component of cash flow, while $PermitCash$ represents the cash flow related to the environmental regulation.

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[12] Rauh (2006) follows a similar strategy and uses mandatory contributions to the pension fund to identify a source of non-operating cash flow.

Finally, we include $X_{i,t-1}$, a vector of firm level controls including the emission rate, ROA, leverage, and total assets. We include total assets to control for the possible relation between firm size and investment. We also include the emission rate, the total amount of SO_2 produced by the utility during the year divided by its total heat input use, to control for any possible differences in investment related to the type of technology of the firm (whether it uses coal, gas or petroleum). The coefficient of main interest for our purpose is β_2, which shows the sensitivity of investment to the cash flow related to the compliance with the environmental regulation.

At this point it is important to mention some caveats of our measure of non-operating cash flow (permit cash flow). While arguably more exogenous to investment opportunities than operating cash flow, there are still possible sources of endogeneity on it. First, firms decide how much they pollute each period, therefore permit cash flow depends on both exogenous components (permit allocation and permit price) and a firm decision (emissions). This could bias our estimate of the relationship between permit cash flow and investment. To partially control for this, the regressions include year dummies and the emission rate. Also, in our robustness check we instrument emissions with its lagged values.

5 Results

In table 2 we present the results of our baseline specifications of the main regression. The dependent variable in both regressions is the ratio of capital expenditures to total assets at the beginning of the period. The second specification (2) regresses the investment rate on the permit cash flow, the operating cash flow, and the emission rate, while the first specification (1) adds as an additional regressor the interaction between $PermitCash$ and the value of assets ($log(A_{i,t-1})$). Both specifications include a full set of year dummies and are estimated with firm fixed effects and robust standard errors.

The results show that, in this sample of electric utilities, the investment rate is on average positively correlated with the permit cash flow. In column (2) the economic and statistically significant coefficient of 1.628 on $PermitCash$ means that firms increase their investment in \$1.628 per \$1 increase in $PermitCash$. Interestingly, firm investment does not seem to be related to the contemporaneous operating cash flow in the same period, the coefficient of 0.007 on $OperatingIncome$ is both small in economic magnitude and is not statistically significant. The coefficients on the firm level controls show that, as firms grow larger, they invest on average less. Also, and a positive correlation between the lagged ROA and investment.

To explore whether the positive coefficient on $PermitCash$ is related to financial constraints, in column (1) we use a more flexible specification that allows the relationship between $Investment$ and $PermitCash$ to vary with the size of the firm. The implicit assumption here is that larger firms are less subject to the financial frictions that may cause a positive correlation between investment and cash flow. Therefore, we expect a negative coefficient on the interaction term between the permit cash flow and firm size. The results in column (1) support this hypothesis. The coefficient on $PermitCash$ is positive and statistically significant, while the coefficient on the interaction of firm size ($Assets$) and $PermitCash$ is negative and statistically significant. That is, the effect of $PermitCash$ on investment is stronger for smaller, arguably more financially constrained, firms.[13]

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[13] We also estimated the models using random effects (RE) instead of fixed effects. The RE model estimated coefficients are of the same sign as those of the FE models, but are generally smaller in magnitude and statistically insignificant. To test for the appropriateness of the RE model in this dataset we perform for both specifications tests of overidentifying restrictions. In models (1) and (2) the Sargan-Hansen test rejects the null of RE in favor of FE. For this reason,

Table 2: The Effect of Permit Cash on Investment

This table shows the results from fixed effects regressions of investment on cash flow, investment opportunities, and firm level variables. The dependent variable is the ratio of capital expenditures to the total assets at the beginning of the period (*Investment*). Cash flow is decomposed into *PermitCash* and *OperatingIncome*. The regressions are estimated with fixed effects and contain a full set of year dummies.

	(1)	(2)
$PermitCash$	6.955***	1.628***
	(1.668)	(0.393)
$PermitCash \times Assets$	-0.882***	
	(0.272)	
$OperatingIncome$	-0.013	0.007
	(0.080)	(0.076)
$EmissionRate$	33.926	33.757
	(23.891)	(23.939)
$Assets$	-0.044***	-0.037***
	(0.009)	(0.009)
$SalesGrowth$	0.002	0.001
	(0.009)	(0.009)
ROA	0.371**	0.389**
	(0.152)	(0.155)
$Leverage$	-0.031	-0.023
	(0.042)	(0.044)
Observations	662	662
R-squared (within)	0.277	0.263
Firms	74	74

Robust standard errors in parenthesis.* significant at 10%,** significant at 5%; *** significant at 1%.

For further analysis, we divided the sample between observations below and above the median of total assets, and below and above the median emission rate. We present these results in tables 3 and 4.

Columns (2) and (3) in table 3 show the results of our baseline regression for the subsample of firms with a total value of assets below and above the sample median respectively. In the sample of small firms, column (2), the coefficient on *PermitCash* is positive and significant, while in the sample of large firms, column (3) it is negative but not significant. Small firms with a one percent higher *PermitCash* invest 1.749 percent more than other small firms. In column (4) we run a similar model with all the observations, and add the interactions between an indicator variable equal to 1 if the firm has total assets below the sample median (*Small*) with *PermitCash* and also with the full set of year dummies (these coefficients are not reported for brevity). The former interaction captures the difference in the average relation of *PermitCash* and *Investment* between small and large firms, while the later interactions capture the differential effect between small and large firms of all the aggregate determinants of investment subsumed in the year indicators. In this specification we obtain results in line with those in columns (2) and (3), the coefficient on *PermitCash*, the marginal effect for large firms, is -0.207 and is statistically insignificant, while the coefficient on the interaction of *PermitCash* and *Small* is positive and statistically significant. The marginal effect of *PermitCash* for small firms is 1.761 (-0.207 + 1.968) and is statistically significant.

The variation in our variable of interest, *PermitCash*, is highly related to the emission rate of the utility. In particular, the standard deviation of *PermitCash* is just 0.1% of the value of assets for firms with an emission rate below the median, and almost 1% of the value of assets for firms with a high emission rate. For this

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we only use FE in the reported regressions.

reason, we perform the analysis for these samples separately, to better identify where are we identifying the coefficients. Column (2) and (3) in table 4 show the results for the low and high emission rate firms respectively. While the sign and magnitude of the coefficients on $PermitCash$ and its interaction with size are similar in both subsamples (7.400 and 9.004 for $PermitCash$, and -0.784 and -1.280 for $PermitCash \times Assets$), they are only statistically significant in the sample of high emission rate firms.

6 Robustness

6.1 Imputed Tobin Q

A potentially important limitation of our data is the lack of stock price information for most firms. This prevents us from using Tobin Q as a proxy of firm level investment opportunities, and forces us to rely instead on the use of sales growth, the return on assets and year dummies to control for them. One approach to circumvent this potential omitted variable problem is to impute Tobin Q at the firm level. Following Campello and Graham (2007) we regress Tobin Q for firms with publicly traded stock on a set of variables that are thought to be related to the marginal product of capital. We first run the following regression for all the electric service firms with coverage on Compustat (SIC codes 4911 and 4931) between 2000 and 2009.

$$TobinQ_{i,t} = \alpha + \beta_1 SalesGrowth_{i,t} + \beta_2 ROA_{i,t} + \beta_3 Leverage_{i,t} + \beta_4 Size_{i,t} + \epsilon_{i,t}$$

Table 3: The Effect of Permit Cash on Investment - Size

This table shows the results from fixed effects regressions of investment on cash flow and investment opportunities for different firm size samples. The dependent variable is the ratio of capital expenditures to the total assets at the beginning of the period (*Investment*). Cash flow is decomposed into *PermitCash* and *OperatingIncome*, *Small* is equal to one if the firm is below the median in assets. All the models contain a full set of year dummies. Column (1) is the baseline regression for the full sample. Column (2) and (3) are the results for the small and large subsamples respectively. The model in column (4) additionally includes a full set of interactions between *Small* and the year dummies.

	(1)	(2)	(3)	(4)
$PermitCash$	6.955***	1.749***	-0.590	-0.207
	(1.668)	(0.375)	(0.868)	(0.858)
$PermitCash \times Small$				1.968**
				(0.863)
$OperatingIncome$	-0.013	-0.270	0.104	0.008
	(0.080)	(0.212)	(0.062)	(0.075)
$EmissionRate$	33.926	34.044	5.157	31.562
	(23.891)	(38.693)	(9.718)	(24.065)
$Assets$	-0.044***	-0.030**	-0.046***	-0.035***
	(0.009)	(0.014)	(0.013)	(0.009)
$PermitCash \times Assets$	-0.882***			
	(0.272)			
$SalesGrowth$	0.002	0.004	0.002	0.002
	(0.009)	(0.015)	(0.003)	(0.008)
ROA	0.371**	0.585**	0.221***	0.382**
	(0.152)	(0.273)	(0.066)	(0.152)
$Leverage$	-0.031	-0.046	-0.013	-0.027
	(0.042)	(0.090)	(0.038)	(0.043)
Observations	662	331	331	662
R-squared (within)	0.277	0.267	0.395	0.287
Firms	74	44	46	74

Robust standard errors in parenthesis.* significant at 10%,** significant at 5%; *** significant at 1%.

Table 4: The Effect of Permit Cash on Investment - Emissions

This table shows the results from fixed effects regressions of investment on cash flow and investment opportunities for different firm emission samples. The dependent variable is the ratio of capital expenditures to the total assets at the beginning of the period (*Investment*). Cash flow is decomposed into *PermitCash* and *OperatingIncome*. All the models contain a full set of year dummies. Column (1) is the baseline regression for the full sample. Columns (2) and (3) are the results for the low and high emission rate subsamples respectively. We divided the sample between observations below and above the median emission rate.

	(1)	(2)	(3)
PermitCash	6.955***	7.400	9.004***
	(1.668)	(17.340)	(2.228)
OperatingIncome	-0.013	-0.049	-0.030
	(0.080)	(0.098)	(0.215)
EmissionRate	33.926	1.318	43.407
	(23.891)	(70.997)	(33.288)
Assets	-0.044***	-0.030*	-0.050***
	(0.009)	(0.015)	(0.015)
PermitCash × *Assets*	-0.882***	-0.784	-1.280***
	(0.272)	(2.181)	(0.397)
SalesGrowth	0.002	-0.008	0.007
	(0.009)	(0.008)	(0.009)
ROA	0.371**	0.134	0.603**
	(0.152)	(0.084)	(0.277)
Leverage	-0.031	-0.105	-0.042
	(0.042)	(0.079)	(0.052)
Observations	662	331	331
R-squared (within)	0.277	0.318	0.314
Firms	74	47	46

Robust standard errors in parenthesis.* significant at 10%,** significant at 5%; *** significant at 1%.

We then use the estimated coefficients[14] to impute Tobin Q for our sample of privately held utilities or, alternatively, as in most of the specifications in the paper, add the full set of Tobin Q regressors as controls in our empirical specification.

Finally, we run the following empirical model:

$$\begin{aligned}\frac{I_{i,t}}{A_{i,t-1}} = \alpha_i + \alpha_t + \beta_1 \frac{ImputedTobinQ_{i,t-1}}{A_{i,t-1}} + \beta_2 \frac{PermitCash_{i,t}}{A_{i,t-1}} + ... \\ \beta_3 \frac{OperatingIncome_{i,t-1}}{A_{i,t-1}} + \beta_4 X_{i,t-1} + \epsilon_{i,t}\end{aligned}$$

The imputed Tobin Q enters the equation lagged one period as investment between $t-1$ and t is supposed to depend on Tobin Q at the beginning of the period (end of $t-1$).

In table 5 we present the result of the regression using the imputed Q as a proxy of investment opportunities. For reference, in the first column we show the benchmark case, which uses the first stage regressors as firm level controls, and it is the same regression in column (1) of table 2. The second column shows the result of the regression using the Imputed Q for all firms. Finally, in the last column, instead of using Imputed Q for all firms, we only impute it for the private firms with no stock price data. We use the actual Tobin Q for the publicly traded firms that have such information.

For all specifications, *PermitCash* is significant and positive as well as *Assets* and the interaction between *Assets* and *PermitCash*. The imputed Q is not significant. However, this could be due to the measurement error that produces an attenuation bias. When we just impute Q for the observations without Tobin Q (column 3) the results are similar.

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[14] The result from this estimation is:

$$TobinQ_{i,t} = 0.605 + 0.068 SalesGrowth_{i,t} + 0.560 ROA_{i,t} + 0.930 Leverage_{i,t} - 0.020 Size_{i,t}$$

Overall, it seems that we do not get much out of Tobin Q imputation exercise, the coefficients of interest remain qualitatively similar and the new proxy for investment opportunities is not significantly related to firm investment.

6.2 Instrumented Emissions

Our variable of interest, $PermitCash$, is the product of the permit price times the discrepancy between the SO_2 permit allocation to each firm and its emissions. However, emissions are endogenously determined within the model. They depend on the price of permits and they may also depend on other variables such as output. If the optimal level of emissions depends on the shock to investment opportunities in ways that are not captured by our investment opportunities controls, then the correlation between $PermitCash$ and investment can not be interpreted necessarily as evidence of financial constraints.

To account for this, we instrumented emissions with its lagged values. We run two stage regressions in which we instrument $PermitCash$ with an analogous construct that depends on each firm's lagged emissions. Table 6 show the results from these estimations. The first column of table 6 shows the baseline case for a benchmark. The second column uses as instrument of $PermitCash_{i,t} = p_t^e \times (\bar{e}_{i,t} - e)_{i,t}$ a one period lag of emissions instrument $PermitCashIV_{i,t,t-1} = p_t^e \times (\bar{e}_{i,t-1} - e)_{i,t}$, the third column uses two lags of emissions, and the fourth column uses three lags.

We obtain similar results to the benchmark case in all of the specifications. The coefficient on $PermitCash$ remains positive, and the coefficient on its interaction with $Assets$ remains negative.

Table 5: Imputed Q

This table shows the results from fixed effects regressions of investment on cash flow and investment opportunities controlling for an imputed Q. Following Campello and Graham (2007) we regress Tobin Q for firms with publicly traded stock on a set of variables that are thought to be related to the marginal product of capital and then used the estimated coefficients to create the Imputed Q. The dependent variable is the ratio of capital expenditures to the total assets at the beginning of the period ($Investment$). Cash flow is decomposed into $PermitCash$ and $OperatingIncome$. All the models contain a full set of year dummies. Column (1) is the baseline regression for the full sample. Column (2) adds the Imputed Q as a regressor and excludes the firm level controls used to calculate it. Finally, column (3) uses the imputed Tobin Q for the firms without publicly traded stock and the actual Tobin Q for the ones with publicly traded stock.

	(1)	(2)	(3)
$PermitCash$	6.955***	7.562***	7.538***
	(1.668)	(1.924)	(1.945)
$OperatingIncome$	-0.013	0.012	0.010
	(0.080)	(0.083)	(0.083)
$EmissionRate$	33.926	34.950	35.096
	(23.891)	(27.652)	(27.646)
$Assets$	-0.044***	-0.066***	-0.064***
	(0.009)	(0.011)	(0.011)
$PermitCash \times Assets$	-0.882***	-0.953***	-0.950***
	(0.272)	(0.307)	(0.310)
$TobinQImp$		0.006	
		(0.044)	
$SalesGrowth$	0.002		
	(0.009)		
ROA	0.371**		
	(0.152)		
$Leverage$	-0.031		
	(0.042)		
$TobinQImp2$			0.004
			(0.019)
Observations	662	662	664
R-squared (within)	0.277	0.243	0.243
Firms	74	74	74

Robust standard errors in parenthesis.* significant at 10%,** significant at 5%; *** significant at 1%.

Table 6: Instrumented Emissions

This table shows the results from fixed effects regressions of investment on cash flow and investment opportunities instrumenting emissions. We instrument emissions using lags of the same variable. In the first column we show the benchmark case for reference. Column (1) is the baseline regression for the full sample. Column (2) instruments *Emissions* with its lagged value; column (3) instruments *Emissions* with two lags; and column (4) instruments *Emissions* with three lags.

	(1)	(2)	(3)	(4)
$PermitCash$	6.955***	5.589***	6.248***	6.246***
	(1.668)	(1.940)	(1.917)	(1.997)
$OperatingIncome$	-0.013	-0.004	-0.009	-0.236
	(0.080)	(0.118)	(0.118)	(0.172)
$EmissionRate$	33.926	25.696*	30.146**	59.955***
	(23.891)	(15.038)	(14.902)	(17.923)
$Assets$	-0.044***	-0.035**	-0.040***	-0.068***
	(0.009)	(0.014)	(0.014)	(0.015)
$PermitCash \times Assets$	-0.882***	-0.789**	-0.826***	-0.749**
	(0.272)	(0.320)	(0.318)	(0.329)
$SalesGrowth$	0.002	0.001	0.001	0.002
	(0.009)	(0.007)	(0.007)	(0.007)
ROA	0.371**	0.393***	0.382***	0.293***
	(0.152)	(0.077)	(0.077)	(0.078)
$Leverage$	-0.031	-0.026	-0.028	-0.023
	(0.042)	(0.046)	(0.046)	(0.047)
Observations	662	662	662	591
R-squared (within)	0.277			
Firms	74	74	74	72

Robust standard errors in parenthesis.* significant at 10%,** significant at 5%; *** significant at 1%.

6.3 Additional controls: cost, age and subsidiary

In this section, we add additional controls that may be correlated with investment opportunities. Table 7 shows the result of three extra models. In the first column we show the benchmark specification for reference.

The variable $FuelCost$ is a weighted average of the cost per MMBTU of fuel that the utility bought during the year (coal, gas and petroleum). If the cost of fuels is related to the price of permits, then the firms could be adjusting their capital stock in response to changes in their costs, and not because of changes in cash flow. With the inclusion of this variable we are controlling for both the cost of the specific fuel and the quantity of the fuel that the utility consumes. The second column of table 7 adds this control. Our result is virtually unchanged by the inclusion of this variable, the coefficients on $PermitCash$ and its interaction with firm size remain consistent with our hypothesis, and $FuelCost$ is not significantly related to investment.

Utilities have plants of different ages. If older firms are closer to the optimal capital stock because of time to build constraints we can expect them to invest less, everything equal. Also, younger firms may be more sensitive to changes in investment opportunities (Jovanovic and Rousseau (2009)). Therefore, distribution of the age of the plants that an utility controls could be related to investment behavior. To control for this, we use the variable $MeanAge$ defined as the mean age of all the plants of the utility each period, and the variance of the age ($VarAge$) of the plants of the utility to control for the dispersion of the distribution. Column (3) shows the results of their inclusion. The coefficient on $MeanAge$ and $VarAge$ are not significant and the results are similar to the benchmark case.

Finally, in the model of column (4) we try to capture any differences in investment behavior that could be related to changes in the publicly traded status of the utility or its parent company. We add two, potentially time varying at the utility level, indicator variables. $TradedParent$ is equal to one if the utility parent company has publicly traded stock or else it is zero, and $TradedStock$ is equal to one if the utility has publicly traded stock. The coefficients on our variables of interest are virtually unchanged, and only the coefficient on $TradedParent$ is significantly different from zero. Its 0.015 coefficient means that firms whose parent moves from private to public invest on average 1.5% more as a fraction of assets.

6.4 Placebo

What if we are capturing investment opportunities with $PermitCash$? As we multiply the permit distortion by the average yearly price of permits, it is possible that this price is capturing the overall condition of the economy and therefore investment opportunities. So far we have only presented circumstantial evidence arguing that the change in permit prices has little to do with fundamental changes in the demand for electricity and more with regulatory uncertainty.

To present stronger evidence in favor of our interpretation we perform a falsification exercise. We run a placebo regression to identify if the price of permits is correlated with macro variables. Our placebos are the GDP growth rate and the unemployment rate, and we use them both at the national and state level.

In addition to $PermitCash$ and its interaction with firm size, we add to the empirical specification the placebo and its interaction with size. The GDP growth *Placebo* is defined as $GDPgrowth \times (\bar{e} - e)$, while the Unemployment placebo is defined as $Unemployment \times (\bar{e} - e)$.

Inclusion of these controls does not affect our main result in any of the specifications. $PermitCash$ remains positive and statistically significant, and its interaction with firm size remains negative and statistically significant at the 1% level, showing the robustness of our result. At the same time, both the *Placebo* and its interaction with firm size are insignificantly different from zero in the four

Table 7: Additional Controls

This table shows the results from fixed effects regressions of investment on cash flow and investment opportunities using other additional controls. The first column shows the benchmark case for reference. Column (1) is the baseline regression for the full sample. Column (2) controls for the cost of fuel, *FuelCost* is a weighted average of the cost per MMBTU of fuel that the utility bought during the year (coal, gas and petroleum). Column (3) controls for the mean age of the utility, *Age*. Finally, column (4) includes dummies for parent and subsidiary firms with publicly traded stock.

	(1)	(2)	(3)	(4)
$PermitCash$	6.847***	6.105***	6.770***	6.844***
	(1.681)	(1.638)	(1.586)	(1.689)
$OperatingIncome$	0.001	0.029	0.006	-0.001
	(0.079)	(0.078)	(0.079)	(0.079)
$EmissionRate$	32.867	25.417	38.522	33.006
	(23.995)	(25.224)	(26.598)	(24.102)
$Assets$	-0.044***	-0.042***	-0.046***	-0.043***
	(0.009)	(0.009)	(0.009)	(0.009)
$PermitCash \times Assets$	-0.863***	-0.775***	-0.840***	-0.862***
	(0.273)	(0.270)	(0.257)	(0.274)
$FuelCost$		-0.000		
		(0.000)		
$MeanAge$			0.000	
			(0.000)	
$VarAge$			0.001	
			(0.001)	
$TradedParent$				0.015**
				(0.007)
$TradedStock$				0.002
				(0.006)
$SalesGrowth$	0.001	0.001	0.001	0.001
	(0.009)	(0.009)	(0.009)	(0.009)
ROA	0.369**	0.395**	0.366**	0.367**
	(0.153)	(0.163)	(0.153)	(0.154)
$Leverage$	-0.024	-0.012	-0.015	-0.026
	(0.041)	(0.045)	(0.039)	(0.042)
Observations	652	614	646	652
R-squared	0.274	0.272	0.277	0.274
Firms	73	71	72	73

Robust standard errors in parenthesis.* significant at 10%,** significant at 5%; *** significant at 1%.

alternative models.

7 Conclusion

Cap-and-trade programs and whether the initial permit allocation matters has received considerable attention in the literature during the last decades. In this paper, we explore a dimension of them that has not been studied yet. In the presence of financial constraints, free permits can affect the capital expenditures of the firm. Using pollution permits, we identify the relation between cash flow and investment.

We define the variable permit cash flow as the value of the discrepancy between a firm's permit endowment and its emissions. Firms with a higher discrepancy will have a permit cash flow that is more exposed to changes in permit prices. Using the heterogeneity in allocation and variation in permit prices, we identify financial constraints for the investor-owned utilities participating in the US SO_2 program. In our sample period, the permit price showed an important variation due to factors not related to investment opportunities. In addition to this, utilities differ on the amount of free permits that they get every period. This constitutes a good experiment to identify the dependence of investment on cash flow.

We study how firm investment varies with the permit cash flow. We run firm fixed effect models controlling for year dummies, emission rate, operating income, total assets and its interaction with the permit cash flow and an imputed Tobin Q and find that the coefficient on the permit cash is positive and statistically significant. When we run the regression by subsets of firms, we find that the effect is more important for smaller firms, dirtier firms and firms with a negative distortion (more emissions than allocations). These results are consistent with small firms in this industry facing financial constraints.

Table 8: Placebo

This table shows the results from fixed effects regressions of investment on cash flow and investment opportunities for different samples of firms. The dependent variable is the ratio of capital expenditures to the total assets at the beginning of the period ($Investment$). Cash flow is decomposed into $PermitCash$ and $OperatingIncome$. All the models contain a full set of year dummies. Column (1) is our baseline regression for the full sample. Column (2) through (5) add a placebo for $PermitCash$ and the interaction of this placebo with the lagged value of assets. In column (2) this $Placebo$ is defined as $GDPgrowth \times (\bar{e} - e)$, in column (3) it is defined as $StateGDPgrowth \times (\bar{e} - e)$, in column (4) it is defined as $Unemployment \times (\bar{e} - e)$, while in column (5) it is defined as $StateUnemployment \times (\bar{e} - e)$.

	(1)	(2)	(3)	(4)	(5)
$PermitCash$	6.847***	5.152**	6.112**	10.155***	7.969***
	(1.681)	(2.317)	(3.028)	(2.236)	(2.633)
$OperatingIncome$	0.001	-0.004	0.004	0.010	0.009
	(0.079)	(0.082)	(0.079)	(0.076)	(0.077)
$EmissionRate$	32.867	37.197	35.678	22.177	27.884
	(23.995)	(26.424)	(25.255)	(22.591)	(24.766)
$Assets$	-0.044***	-0.048***	-0.044***	-0.037***	-0.041***
	(0.009)	(0.011)	(0.011)	(0.009)	(0.010)
$PermitCash \times Assets$	-0.863***	-0.635*	-0.749*	-1.274***	-0.987**
	(0.273)	(0.352)	(0.418)	(0.337)	(0.382)
$Placebo$		16,569.182	11,177.803	-8,359.565	913.257
		(16,900.943)	(9,158.210)	(16,402.899)	(15,135.664)
$Placebo \times Assets$		-2,039.445	-1,908.677	185.094	-947.268
		(3,360.370)	(1,973.075)	(3,110.692)	(2,691.794)
$SalesGrowth$	0.001	0.002	0.001	0.000	0.001
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
ROA	0.369**	0.370**	0.373**	0.357**	0.369**
	(0.153)	(0.157)	(0.157)	(0.152)	(0.157)
$Leverage$	-0.024	-0.026	-0.027	-0.023	-0.025
	(0.041)	(0.041)	(0.040)	(0.042)	(0.041)
Observations	652	652	645	652	645
R-squared (within)	0.274	0.278	0.275	0.280	0.276
Firms	73	73	73	73	73

Robust standard errors in parenthesis.* significant at 10%,** significant at 5%; *** significant at 1%.

Further we show that the main result is robust to the inclusion of additional controls, endogeneity concerns, and falsification exercises.

Our approach contributes to the empirical literature in corporate finance relating investment to cash flow. We study a novel “natural experiment” that allows a clean identification of the relationship between cash flow and investment, the component of cash flow related to the allocation of pollution permits.

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