The U.S. Acid Rain Program and Its Effect on SO2 Emission Levels

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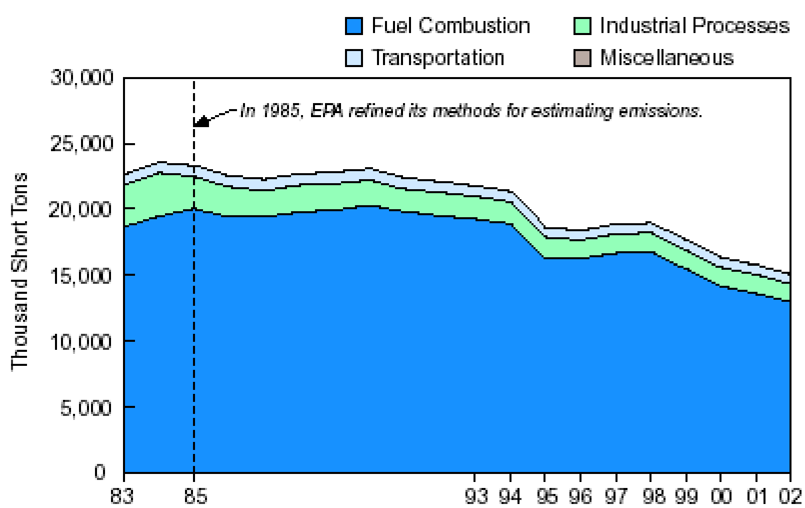
In our world of rapid industrialization and scarce natural resources it is imperative that the United States and other countries find a cost-effective way to reduce pollution. For years the most prevalent means of pollution control were command-and-control reduction methods. Command-and-control methods rely on government bureaucrats to set pollution standards and then enforce them through the use of monetary fines. Beginning in the late 1960's the thought of using economic incentives to control pollution levels started to emerge and by 1975 the first permit trading programs had begun (Tietenberg, 1). Permit trading programs work by allowing pollution sources that decrease discharges more than the set standard to amass pollution permits. Other firms that cannot meet standards can then buy up these permits. In theory incentive based programs are said to be better than traditional command-and-control programs because they are more cost-effective in the short-run, increase incentives to seek out new technology in the long-run, reduce the costly burden of information gathering for regulatory bureaucrats, and are more flexible. On the other hand, there have been some criticisms of these new programs, one of which is that permit trading will lead to condensed areas of pollution known as "hot-spots" (Goodstein 2002, 300).

As part of the Clean Air Act Amendments of 1990 the United States enacted The Acid Rain Program to achieve a decrease in sulfur dioxide (SO2) and nitrogen oxides (NOx), which are the leading causes of acid rain. This study will focus on the program's regulation of SO2 emissions. The area of this program dealing with SO2 is compromised of two phases; Phase I began in 1995 and focused on decreasing the emissions from the 110 most polluting sources, Phase II began in 2000 and further limited emissions from all large sources as well as any new sources. The program works by distributing pollution permits among the firms based on historical pollution levels. Unused permits may be sold, traded, or banked for future use. Sources that pollute in excess of the permits they hold are penalized. So far the Acid Rain Program has been very successful and is well on the way to meeting its goal emission level of 8.95 million tons by 2010—a 50% reduction from 1980 levels (EPA b 2002, 1-3) (see Figure 1, notice the drop in emissions at the start of the Acid Rain Program in 1995). Although this program has been successful, the problem of pollution hot-spots has not been adequately addressed and still may be a very real threat.

Figure 1: SO2 Emissions, 1983-2002



(Source: EPA a 2003)

This paper will address the question of whether permit trading programs are one of the main contributing factors of SO2 emission levels. Answering this question will help to determine whether permit trading programs are a leading cause of pollution hot-spots. The question will be answered through the use of regressional analysis using SPSS and data from the U.S. Acid Rain Program. Section I will provide a review of the literature pertaining to this topic. Section II will introduce the economic model used in this study. Section III will review the results. Section IV will discuss potential econometric problems in the model and Section V will provide some concluding remarks as well as policy recommendations.

I. Literature Review

The literature regarding permit trading programs and their effect on SO2 emission levels falls into 3 main categories: information about permit trading programs in general and the economic theories that underlie them, information about the specific Acid Rain Program, and finally information about the problem of hot-spots in relation to the Acid Rain Program.

A. PERMIT TRADING PROGRAMS

Permit trading programs allocate pollution permits to firms and then allow firms who reduce pollution discharge below set standards to either trade permits away or bank them for future use. Permit trading programs are expected to work more efficiently than traditional command-and-control programs for four reasons: they are more cost-efficient in the short-run, they increase incentives to seek out new technology in the long-run, they reduce the costly burden of information gathering for regulatory bureaucrats, and they are more flexible. Trading programs are more cost-efficient because the firms with the lower marginal costs (MC) of pollution reduction will reduce pollution, while the firms with higher MC of reduction will elect to purchase pollution permits from other firms. In this way, pollution will get reduced at a much lower cost than if command-and-control regulation was imposed upon firms no matter their MC of reduction. Trading programs increase incentives to seek out new technology in the long-run because the incentive to further reduce pollution to free-up more permits to be sold is always there. Traditional command-and-control programs force firms to adopt cleaner technology and reduce pollution up to a certain point, but after firms have reached this point the incentive to further reduce pollution disappears. Trading programs reduce the costly burden of information gathering for regulatory bureaucrats because regulators need only to specify a number of permits to be issued and let market forces take over. In command-and-control programs regulators need to first determine the best technology available (which is a long and costly procedure) and then see to it that all firms make use of this technology (Goodstein 2002, 300). Finally, trading programs are more flexible because they can more easily accommodate change whether it is of environmental quality standards, economic conditions, or abatement technologies. In the case of changing economic conditions or new technologies the regulator does not need to take action to alter regulatory laws as the system can absorb these changes. Changing environmental quality standards can simply be dealt with by limiting the quantity of permits issued (Blackman and Harrington 2000, 13).

There are also a number of potential problems associated with permit trading programs. These problems include thin markets, development of market power, relocation effect, problems in monitoring, and hot-spots (Goodstein 2002, 309). Thin markets are markets in which there are few buyers and sellers; this is a problem because a small number of traders will yield a low probability of getting a good deal and therefore even less firms will be willing to enter into the market. Development of market power would be a problem because existing firms could refuse to sell permits to new firms to limit competition, creating barriers to entry. The relocation effect is the fear that firms will be enticed to sell all their permits and then relocate to an area with less stringent pollution regulation (Mexico for example). Trading programs rely on monitoring to determine the amount of pollution leaving a source. If monitoring cannot be properly regulated firms may be able to cheat and pollute large amounts without the need to buy permits. Monitoring is more of a problem for mobile sources (such as monitoring car emissions) than stationary sources (such as power plants which are the focus of the Acid Rain Program). Another criticism of permit trading programs is that they will lead to hot-spots, or high local concentrations of pollution. Trading programs allow firms to pollute as long as they obtain pollution permits, so the fear is that certain firms will emit great amounts of pollution leading to hot-spots. Economists feel that actions can be taken to reduce the risk of hot-spots. One such suggested action is that taxes be placed on the contribution of emissions to ambient air quality; taxes would be higher in areas where air quality is already bad (Goodstein 2002, 309-312). Some measures have been taken to prevent hot-spots in the Acid Rain Program, these measures and their apparent effectiveness will be discussed later in the literature review.

B. THE ACID RAIN PROGRAM

The Acid Rain Program's goal is to reduce sulfur dioxide (SO2) and nitrogen oxides (NOx), which are the leading causes of acid rain. This study will focus on the program's regulation of SO2 emissions. The program aims to reduce SO2 emissions by 50% of the 1980 levels through a two phase program that will mandate all large and new SO2 polluters to cut emissions. Besides the firms mandated to reduce emissions there is also an Opt-in Program that expands the Acid Rain Program to include additional SO2 emitting sources. The Opt-in program was established by Congress under section 410 of the Clean Air Act Amendments of 1990. The Opt-in program is expected to reduce the cost of achieving the program's goal by attracting SO2 sources with low marginal costs of compliance. These sources will voluntarily enter into the system, reduce emissions, and then sell their emission permits to other firms with high marginal costs of pollution reduction. Under the SO2 program the U.S. government allocates pollution permits to firms every year based on their historical pollution levels. In addition the EPA holds yearly permit auctions. These auctions help to send market permit pricing signals as well as create another venue for firms to obtain permits. Pollution permits may be used during the year obtained or any year thereafter. Each permit allows a firm to emit one ton of SO2. At the end of each year the firm must hold at least as many permits as their annual emissions. For every ton of SO2 over the number of permits a firm holds, the firm will have to pay a fine of $2000 and forfeit the equivalent number of permits for the next year as a punishment (Tietenberg, 7). However, no matter how many permits a firm holds it may not pollute in excess of the limits set under Title 1 of the Clean Air Act in place to protect public health. The EPA keeps track of permit trades to ensure that at yearend a firm's emissions do not exceed the number of permits it holds through an Allowance Tracking System (ATS) (EPA b 2002, 1-4). The ATS is an electronic recordkeeping system that keeps track of the transactions as they happen and holds allowance accounts for all firms in the market.

Once permits are obtained they can be traded in any one of three programs or banked for future use. The three trading programs established under the Acid Rain Program are offset, netting, and bubble policy. Offset policy deals with the siting of new pollution sources in non-attainment areas. New sources may locate in non-attainment areas if, depending on the severity of the existing pollution, they purchase between 1.1 and 1.5 pollution permits for every ton of emissions they plan to emit. Offset policy was designed to balance economic growth with pollution control. Netting policy allows expanding firms to escape the stringent technological requirements for pollution control in new sources as long as pollution permits from within the firm offset any increase in emissions. Much like offset policy, netting policy balances economic growth with pollution control. Unlike the other two programs, bubble policy was designed primarily to generate cost savings and works most like the theoretical permit trading program model. Bubble policy allows pollution to be regulated on a plant-wide basis instead of stack-by-stack. An imaginary "bubble" is placed over the plant and emission standards have to be met by the plant as a whole instead of by each smokestack (Goodstein 2002, 330-331 and Tietenberg, 3-4).

C. HOT-SPOTS AND THE ACID RAIN PROGRAM

Limited literature can be found on the effects of the Acid Rain Program on pollution hot-spots. In his working paper Tietenberg says that the Acid Rain Program attacks the hot-spot problem through "regulatory tiering." Regulatory tiering involves applying more than one regulatory regime at a time in an attempt to exercise some control over how permits are used. The Acid Rain Program layers permit trading over a more traditional system of regulations. As mentioned in the previous section the program does not allow firms to pollute in excess of the limits set under Title 1 of the Clean Air Act. In this manner trading is constrained by the need to meet these air quality standards. These standards are set to protect ambient air quality standards and prevent violations against them, but do not protect citizens from all air quality deterioration. So although the government has taken some measures to prevent hot-spots, according to Tietenberg their creation is still a possibility (Tietenberg, 24-25).

Another author who has written on the subject of hot-spots and the Acid Rain Program is Swift (2000). Swift writes that after the first four years the Acid Rain Program has had a minimal and likely positive effect on hot-spots. Swift states that in practice trading may be expected to have little relation to hot-spots in the first place for three main reasons. Swift's first reason is the one Tietenberg discusses in his writing. The potential for hot-spots must be looked at in the overall regulatory context and since the Acid Rain Program incorporates a number of other pollution standards, any reductions made from trade are over and above these standards. Because of the air quality standards in place Swift writes that it is virtually impossible for trading under the Acid Rain Program to create hot-spots. Swift's second reason is that there are many other relevant factors that may contribute to hot-spots. Other factors such as plant location, size, and fuel utilization are often more important than permit trading in leading to hot-spots. Swift's third reason is that since the motive to trade is economic permit flows are expected to be random. In fact, the only detectable pattern is that large plants might reduce pollution the most because they are expected to have the cheapest per-unit marginal costs of reduction (Swift 2000, 954-959).

Swift goes on to examine total SO2 emissions by state compared to the total number of permits issued to that state. Swift finds that the three major regions (Mid Atlantic, Midwest, and Southeast) are quite consistent in terms of emissions versus permits issued with total emissions between 64 and 77 percent of permits issued. Swift also looks at the net flows of permits used to offset emissions and finds that 81 percent of permits used to offset emissions come from within the state. In fact, between 1995 and 1999 only 3 percent of total emissions represent net inter-regional transfers. Swift's findings also confirm his hypothesis that plants with the largest emissions will clean up the most. Emissions are 24 percent below permit levels for the largest plants while only 6 percent below for the smallest plants. Based on his findings Swift concludes that if anything trading programs may be expected to cool hot-spots by motivating the largest firms and therefore the biggest polluters to clean up (Swift 2000, 954-959).

Since Swift's findings the Acid Rain Program has embarked upon Phase II and had three more years of permit trading and data collection. This study will use Ordinary Least Squares analysis to determine if permit trading is a major contributing factor of SO2 emission levels or if, as Swift suggests, other factors such as plant size, fuel utilization, and SO2 controls play a larger role. If permit trading is shown to be one of the main contributing factors of SO2 emission levels it can be inferred that permit trading is a leading cause of large areas of localized pollution, or hot-spots.

II. Economic Model

This study will run linear regressions to determine whether tradable pollution permits are one of the main contributing factors of SO2 emission levels. The economic model used in this study will look at SO2 emissions as dependant upon plant size, primary fuel type, SO2 controls, and net flow of tradable permits.

(1) SO2 emissions = f (plant size, fuel type, SO2 control, permit net flow)

(2) $EMIS = b_0 + b_1 SIZE2 + b_2 FUELDUM + b_3 CONTDUM + b_4 PNET$

SO2 emissions (*EMIS*) data will be used from plants that are active participators in the emissions trading component of the Acid Rain Program and will be measured in tons per year. Participators in the Acid Rain Program measure the rate at which SO2 is released and then calculate the total SO2 released per year based on the emission rate per hour and total operating hours for the year (EPA c 2003). All data used in this study is from the most current year available, 2002.

The independent variable plant size (*SIZE2*) is inferred through the use of a proxy variable heat input (in million British thermal units). Heat input is a measure of heat utilization and can be calculated by multiplying the quantity of fuel used within a plant by the fuel's heat content (EPA c 2003). Larger plants, which use more fuel, have a greater heat input while smaller plants have a smaller heat input; therefore heat input can be used as a measure of plant size. To more clearly see the changes in SO2 emissions due to changes in plant size the heat input data was recoded. Heat input was broken down into ranges and recoded as is seen in Table 1. All else being equal, larger plants produce more SO2 emissions. Thus, the variable *SIZE2* will be positively related to SO2 emissions and the beta coefficient b_1 will have a positive sign.

Table 1: Recoding for *SIZE2*

Heat Input Range	Recoded Value
lowest value? 4,999,999	0
5,000,000? 9,999,999	1
10,000,000? 14,999,999	2
15,000,000? 19,999,999	3
20,000,000? 24,999,999	4
25,000,000? 29,999,999	5
30,000,000? 34,999,999	6
35,000,000? 39,999,999	7
40,000,000? 44,999,999	8
45,000,000? 49,999,999	9
50,000,000? 54,999,999	10
55,000,000? highest value	11

(Source: EPA d 2002)

The variable primary fuel type (*FUELDUM*) is a dummy variable. The three main fuel types used in power plants are coal, oil, and natural gas. According to the EPA coal consists of all solid fuels classified as anthracite, bituminous, subbituminous, or lignite by the American Society for Testing Materials Designation ASTM D388-92 "Standard Classification of Coals by Rank" (EPA c 2003). The primary fuel for a plant is that which is used most intensively by the plant. A number of plants have a primary fuel type and then a secondary or backup fuel type. For this model coal is coded as 1 and everything else is 0. Coal is considered the dirtiest burning of the three fuels because it produces the greatest SO2 emissions. Thus, a plant which primarily uses coal as a fuel source is expected to have higher SO2 emission levels and therefore the beta coefficient b_2 will carry a positive sign.

SO2 control (*CONTDUM*) is also a dummy variable. A number of plants have installed SO2 controls that reduce the production or emission of SO2. SO2 controls installed by plants in the Acid Rain Program include magnesium oxide, dual alkali, dry lime FGD, fluidized bed limestone injection, sodium based, wet lime FGD, and wet limestone (EPA c 2003). For this model plants that have some form of SO2 control are coded as 1 while plants without are coded as 0. It is expected that plants coded 1 will have less SO2 emissions and therefore the beta coefficient b_3 will carry a negative sign.

The variable permit net flow (*PNET*) measures the number of permits flowing into and out of a plant through buying/selling of permits. To calculate the data for *PNET* I subtracted permits sold from permits bought for all the plants participating in the emissions trading program. A plant with a large number of permits flowing into it is expected to have higher SO2 emissions because the permits are used to allow the firm to pollute. A plant with a large number of permits flowing out of it is expected to have lower SO2 emissions because it is reducing pollution instead of buying up permits. A plant with a high permit net flow is one which has a larger number of permits flowing into it and a small number flowing out of it. While a plant with a low permit net flow is one that has a small number of permits flowing into it and a larger number flowing out of it. Thus, a plant with a high permit net flow is expected to have greater SO2 emissions than a plant with a low permit net flow. Consequently, the independent variable *PNET* is positively related to SO2 emissions and the beta coefficient b_4 will carry a positive sign.

The next section of this paper will explain the regressions run using this model and their results.

III. Results

This study uses a linear regression model to determine whether emission trading programs are one of the main contributing factors of SO2 emission levels. A traditional linear regression may be used in this study because the independent variables are expected to have a roughly linear relationship to the dependant variable.

This study uses data found on the EPA's "Clean Air Markets – Acid Rain Program" website. The data for plant size, fuel type, and SO2 controls can be found as part of the "2002 Acid Rain Emissions Data and Unit Characteristics" and can be accessed at <http:// www.epa.gov/airmarkets/arp/index.html> (EPA d 2002). This data is collected by the EPA and is a listing of all the units taking part in the SO2 component of the Acid Rain Program. The data includes yearly emission and unit characteristic data by unit id. The data for permit net flow was provided to me by Alex Salpeter of the Office of Air and Radiation for the EPA Headquarters in Washington, D.C. (Salpeter 2003, Personal Communication). Mr. Salpeter generated a list of permits bought and sold in 2002 by account number (which corresponds to the unit id). This data can be generated using the "Interactive Online Reports for Transactions" found at <http://www.epa.gov/ airmarkets/tracking/ats/ transactions.html>. Once you have downloaded the transaction data for 2002 you can generate a list of the permits bought and sold by adding the amount of permits involved in the transfers for each account, once for each account as transferee (these are the permits bought) and once for each account as transferor (these are the permits sold). Once I had both data sets I matched up the account numbers in my permits data to the unit ids in my emissions and unit characteristics data to generate a complete data set. A number of the plants participating in the Acid Rain Program, and therefore included in the "2002 Acid Rain Emissions Data and Unit Characteristics" data, did not buy or sell permits in 2002. Plants that had not bought or sold permits in 2002 were left out of my ending data set because since they were not actively participating in the program I felt that their data would skew my results. In other words, plants not actually trading permits would not help to determine whether permit trading was a main contributing factor of SO2 emission levels. In the end I had 1695 data points each which include: plant name, state (where the plant is located), unit id, fuel type, SO2 controls, yearly SO2 emissions, plant size, permits bought, permits sold, and net permit flow. From this data I was able to compute my dummy variables for fuel type and SO2 controls as well as my recoded variable for plant size.

As you can remember from section III the regression equation used is:

$$EMIS = b_0 + b_1 SIZE2 + b_2 FUELDUM + b_3 CONTDUM + b_4 PNET \quad (2)$$

In review (refer to section III for more detail), the independent variables *SIZE2*, *FUELDUM*, and *PNET* are expected to have a positive relationship to the dependent variable *EMIS*. The independent variable *CONTDUM* is expected to have a negative relationship to the dependent variable *EMIS*. A table reviewing the expected signs on the beta coefficients for each independent variable is shown below (Table 2).

Table 2: Expected Signs on the Coefficients

Variable	Expected Sign
SIZE2	+
FUELDUM	+
CONTDUM	-
PNET	+

The results of my regression are summarized in Tables 3 and 4 below. The Adjusted R Square value indicates that the regression model explains roughly 63% of the variation in SO2 emission levels. The beta coefficient for *SIZE2* has the expected sign and a value of 2204.28. The beta coefficient for *FUELDUM* has the expected sign and a value of 5108.83. The beta coefficient for *CONTDUM* has the expected sign and a value of -9911.87. The beta coefficient for *PNET* has the expected sign, but a relatively small value of 0.06. The significance levels were below .01 for every independent variable and therefore the beta values are all significant at a 99% confidence level. The null hypothesis, which is that the beta is less than or equal to 0 can easily be rejected. The modified equation, including the beta values, is as follows:

(3) $$EMIS = -425.88 + 2204.28(SIZE) + 5108.83(FUELDUM) - 9911.87(CONTDUM) + 0.06(PNET)$$

These results can be interpreted in the following ways. The coefficient on *SIZE2* indicates that a one step move upwards in the size of a plant will increase yearly SO2 emissions by roughly 2200 tons, holding *FUELDUM*, *CONTDUM*, and *PNET* constant. The coefficient on *FUELDUM* indicates that plants that use coal as a primary fuel type will emit about 5110 more tons of SO2 than a plant that uses another fuel type, holding the other variables constant. The coefficient on *CONTDUM* indicates that plants that have installed SO2 controls emit approximately 9910 less tons of SO2 per year than plants that have no SO2 controls, holding the other variables constant. The coefficient on *PNET* indicates that for plants with a positive net balance of permits traded every extra permit bought over and above a balance of zero would increase SO2 emissions by 0.06 tons per year, holding the other variables constant. This coefficient also indicates that for plants with a negative net balance of permits traded every permit sold below a balance of zero would decrease SO2 emissions by 0.06 tons per year. While this coefficient may seem small one must remember that it only indicates the change in emissions for every one permit. When one multiplies this coefficient by the value of *PNET* one will often see that permit trade does in fact have a large impact on SO2 emissions.

Table 3: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.794[a]	.631	.630	5599.569

[a] Predictors: (Constant), SIZE2, PNET, CONTDUM, FUELDUM

Table 4: Data on the Coefficients

	Unstandardized Coefficients		Standardized Coefficients		
Model 1	**B**	**Std. Error**	**Beta**	**t**	**Sig.**
Constant	-425.884	193.455		-2.201	.028
CONTDUM	-9911.870	485.615	-.335	-20.411	.000
FUELDUM	5108.826	321.169	.278	15.907	.000
SIZE2	2204.276	58.065	.681	37.962	.000
PNET	0.061	.006	.142	9.586	.000

Dependent Variable: EMIS

The regression results show that for plants actively participating in the Acid Rain Program the net flow of tradable pollution permits can have a large impact on SO2 emissions, but this impact is often not as large as for other contributing factors. To get a better idea of the importance of permit net flow in determining SO2 emissions one can look at the values of the standardized coefficients. *PNET* has the lowest value on the standardized coefficient, merely .142. This value indicates that when *PNET* changes by 1 of its standard deviations, *EMIS* will change by .142 of its standard deviations. The absolute values of the standardized coefficients for the other independent variables are larger than that of *PNET*. The larger values indicate that when these variables change by one of their standard deviations, *EMIS* will change by more than it does for *PNET*. In simple terms, the standardized coefficients show that *CONTDUM*, *FUELDUM*, and *SIZE2* have a greater influence on SO2 emissions than *PNET*. Therefore, when one looks at the impact of tradable pollution permits on SO2 emissions relative to other contributing variables, one sees that participation in clean air markets has a small affect.

Since the results have shown that the number of permits traded has, on average, a small impact on SO2 emissions, one can infer that the Acid Rain Program is not leading to hot-spots of pollution. If hot-spots are occurring they are more likely due to other factors, such as plant size, fuel type, and SO2 controls, which play a larger role in influencing SO2 emissions.

The next, and final, section of this paper will provide some concluding remarks as well as policy recommendations and suggestions for further research.

IV. Potential Econometric Problems

Two potential econometric problems that must be addressed in this study are multicollinearity and heteroskedasticity. These two potential problems will be tested for and it will be shown that it is unlikely that they exist in the model.

Multicollinearity occurs when the assumption that no explanatory variable is a perfect linear function of any other explanatory variables is violated (Studenmund 2001, 244). To test for multicollinearity in this model a correlation matrix was run (see Table 5). Although there is no set correlation value for above which we can assume multicollinearity, most of the values in the table are quite low. When the value equals zero there is no correlation, when the value equals 1 the variables in question are fully correlated. Remember that when looking at the correlation matrix the correlations between the dependent variable and the independent variables do not need to be considered. This being said the range of absolute correlation values is between .023 and .509. These values are all low enough so that it can be said that multicollinearity is not a likely problem in this model.

Table 5: Correlation Matrix

Pearson Correlation

	EMIS	CONTDUM	FUELDUM	PNET	SIZE2
EMIS	1.000	.031	.519	.187	.691
CONTDUM	.031	1.000	.339	-.023	.405
FUELDUM	.519	.339	1.000	.059	.509
PNET	.187	-.023	.059	1.000	.031
SIZE2	.691	.405	.509	.031	1.000

The next econometrics problem that must be tested for is heteroskedasticity. Heteroskedasticity occurs when the assumption that the variance of the error term is constant is violated (Studenmund 2001, 346). To test for heteroskedasticity in the model a Park test was run. To perform a Park test first the residuals of the regression equation had to be found. Then these residuals are used to form the dependent variable in a new double-log regression. The general double-log equation used is as follows:

(4) $\ln(\text{residual}^2) = a_0 + a_1\ln(Z)$

In this equation Z is the explanatory variable that may be causing variance of the error term (Studenmund 2001, 357). The Park test tests the significance of ln(Z) in explaining $\ln(\text{redisual}^2)$. Park test were run using the explanatory variables *SIZE* and *PNET*. The output on the coefficients from these regressions is in Tables 6 and 7.

Table 6: Data on the Coefficients for Park tests

	Unstandardized Coefficients		Standardized Coefficients		
Model 1	**B**	**Std. Error**	**Beta**	**t**	**Sig.**
Constant	2.819	.380		7.416	.000
LNSIZE	.792	.025	.626	31.774	.000

Dependent Variable: LNRESSQU

	Unstandardized Coefficients		Standardized Coefficients		
Model 1	**B**	**Std. Error**	**Beta**	**t**	**Sig.**
Constant	12.426	.118		105.574	.000
LPNET	.402	.019	.532	21.322	.000

Dependent Variable: LNRESSQU

To complete the Park test the significance of a_1 must be tested. If a_1 is significantly different from zero then there is likelihood of heteroskedastic patterns in the residuals. a_1 is significantly different than zero if the t-value is above 2.576 (Studenmund 2001, 357 + 360). For both the Park tests run the t-value is well above 2.576 so there is likelihood of heteroskedastic patterns in the residuals of this model. Heteroskedasticity is a potential problem with this model, but thankfully this problem does not introduce bias so the values of the beta coefficients can still be trusted. Heteroskedasticity does cause Ordinary Least Squares to tend to underestimate the variances and standard errors of the beta coefficients, therefore the values of the t-statistics and the F-statistic may not be relied upon in the model (Studenmund 2001, 352-354). This is an important problem to bear in mind when looking at this study.

V. Conclusion

Both the previously published literature and the empirical evidence presented in this paper suggest that permit trading programs are not contributing to areas of increased emissions. Previously published literature, namely that by Swift (Swift 2000, 954-959), asserts that the U.S. Acid Rain Program has had minimal and likely positive effects on pollution hot-spots. One of the reasons that Swift believes that the program has not contributed to hot-spots is because other factors such as plant size and fuel utilization play a larger role in determining emission levels. The empirical evidence presented in this paper supports Swift's statement that the Acid Rain Program has had a minimal effect on hot-spot creation, but the findings do not show the positive effect that Swift suggests. The regression results show that while permit net flow does have a small positive effect on SO2 emission levels, other variables such as plant size, fuel type, and SO2 controls play a much larger role in dictating SO2 emission levels. An abbreviated table of the coefficients is as follows (Table 6):

Table 7: Summary of Beta Coefficient Values

Independent Variable	Beta Coefficients
SIZE2	2204.276
FUELDUM	5108.826
CONTDUM	-9911.87
PNET	0.061

One of the major criticisms of permit trading programs is their potential to create hot-spots. This study shows that permit trading programs have only a small effect on emission levels and therefore it is highly unlikely that trading programs are contributing to hot-spots. The implication of this finding is that the worry of hot-spots should no longer prevent legislators from enacting permit trading programs. One policy recommendation based on this implication is that more incentive based programs be put into place. The uses of incentive based regulation are not only environmental, but multiple in nature. The potential for incentive based regulation is high and incentive based programs should be utilized more readily. Another policy recommendation based on this study is that the safeguards against hot-spot creation used in the Acid Rain Program be more closely explored and applied to other permit trading programs. If it is determined that the safeguards used in the Acid Rain Program are in fact the reason permit net flow has such a low impact on emissions it would be a good idea to apply these safeguard to other permit trading programs.

Of course, this study has limitations. For one, it only looked at the U.S. Acid Rain Program which is a program that was put in place alongside safeguards against potential problems such as hot-spots. It is probable that the data shows permit net flow as having a small effect on SO2 emissions because of these safeguards. Another limitation of this study is that the model only accounts for 63% of the variation in SO2 emission levels. While the Adjusted R Square value of .630 is certainly not bad, it could be higher. Another potential econometric problem discussed at length in the previous section is heteroskedasticity.

The limitations of this study lead to a need for further research in the area. Further research could include looking at another permit trading program. It would be interesting to look at a program outside the United States to see if the potential for hot-spots is greater in countries where safeguards against this problem and other problems are probably not in place. Another opportunity for further research would involve expanding upon the current model. Perhaps further research of the literature could yield other independent variables that could be included in the model to make it more accountable. Yet another opportunity for further research could involve remediation of the heteroskedasticity in the model. The heteroskedasticity in the model must be addressed to be able to more accurately gage the significance of the model. These are just a couple suggestions for further research; this topic has numerous avenues that are yet to be explored. The need for cost-effective pollution reduction is greater than ever before and incentive based regulation seems to satisfy this need. More research in the area of incentive based regulation is essential not only for today, but to ensure our planet's future.

VI. References

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