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Impact of Air Quality Regulations on Entrepreneurial Activity

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The objective of this paper is to examine the impact of NAAQS non-attainment status on the entrepreneurial activity in a metropolitan statistical area (MSA). Most of the existing research on the relationship between non-attainment and the financial robustness of areas focuses on the big polluters (e.g., plastics, organic chemicals, steel smelting and refining, etc.), and examines how many of the big polluters failed or relocated, measured by the change in the number of plants/businesses when an area moved from attainment to non-attainment. Our paper will use a 306 MSA panel data set over the 1989-2003 timeframe, to address the question more comprehensively by looking at all industries, not just a targeted few polluters. Controlling for other time-variant confounding effects, such as population growth, per-capita income, tax rate changes, minimum wage rates, energy costs, regional inflation measures, and spatial phenomena (such as, natural disasters) we isolate the effect of non-attainment status on large polluters as well as the linkage industries. We show that if an area is designated non-attainment status in a particular year, it leads to a decline in the total number of business starts in the MSA in the following year. We also determine whether the impact of non-attainment varies across businesses of different sizes.

Introduction

The Environmental Protection Agency (EPA) Office of Air Quality Planning and Standards (OAQPS) has the authority to formally designate areas using the National Ambient Air Quality Standards (NAAQS) for major criteria pollutants and accordingly evaluate an area's attainment status. An area is deemed in attainment by the EPA when the air quality is monitored and the resultant concentrations are found to be consistently below the NAAQS. If the pollution limits are exceeded for several consecutive years, the EPA will designate an area as non-attainment. The area will subsequently be subject to more stringent regulatory requirements and polluting business will be required to adopt measures to alleviate the area's air quality. Therefore, not surprisingly, non-attainment status designations are increasingly becoming a major concern for regional economic viability and attractiveness as a location choice for new business/venture formations.

A considerable amount of literature exists on air quality regulation and its relationship to economic activity. Two distinct streams of research have emerged out of it. The first is the relationship between economic growth and the environment regulation known in the literature as the 'Environmental Kuznets Curve' (EKC)[i]. Although support from the empirical research is divided, the EKC is often offered as a rationale for encouraging economic growth as the best environmental policy option (Beckerman, 1992, Grossman and Krueger, 1993, 1995). Recent evidence shows, however, that the methodologies commonly used in EKC analysis contain important econometric weaknesses (Stern, *et al*., 1996; Stern 2004). Research addressing several of these weaknesses associated with the estimation of EKCs suggests that meaningful EKCs only exist for local air pollutants (Dinda, 2004; Millimet, *et al*., 2003) but these results generally contain some positive bias (List and Gallet, 1999). Thus, the lack of conclusive empirical evidence proving that the EKC is an adequate guide for environmental policy-makers only strengthens the argument for more stringent regulations and enforcement.

The second stream focuses on the relationship between air quality and firm (manufacturing plants) location choices. The general theoretical assumption is that lax environmental regulatory standards attract capital flows (Kahn, 1997; List and Mason, 2001) and yet the empirical evidence is divided. Over the years, researchers have made significant progress in measuring the effects of federal environmental regulations on ambient concentration of several criteria pollutants and business location decisions[ii]. These studies have varied by the time period, type of pollutant and level of data aggregation (county vs. monitor level studies). Although it is reasonable to assert that regulations matter, over the years studies on air quality regulation have found that local regulation has little or no effect on either air quality (MacAvoy, 1987) or business location decisions (Bartik, 1988; Duffy-Deno, 1992; McConnell and Schwab, 1990; Levinson, 1996). Even in recent years, air quality attainment status and plant location decisions have been found to be largely uncorrelated (List, *et al*, 1999), except for large manufacturing plants (Becker and Henderson, 2000; Henderson, 1996; Keller and Levison, 1999; List, 2001; List, *et al*. 2004) in which case, stricter standards are expected to lead to the creation of pollution havens[iii] (List and McHone, 2000).

Some of the counter-intuitive results could in part be attributed to the use of cross-sectional data and/or estimation methods. Cross-sectionally, the location of polluting activity, high concentration readings from certain monitors, and non-attainment status are all highly positively correlated. So the facts that air quality is worse in these areas, and that more polluting businesses are found there are not at all surprising. Panel estimation controls for this cross-sectional correlation and therefore, is used to correctly measure how a change in attainment designation affects new business births (Henderson 1996). But even with panel estimation methods, researchers have failed to show a negative association between environmental regulation and industrial activity (Henderson, 1996; Levinson, 1996; Becker and Henderson, 2000, 2001[iv]). Some research suggests that instead of harming regulated businesses or their workers, environmental regulations may even benefit them (Porter and van der Linde, 1995; Berman and Bui, 2001a, 2001b).

It is important to mention here that most of the studies on the relationship between non-attainment status and the industrial activity in non-attainment areas focuses on the big polluters (e.g., plastics, organic chemicals, steel smelting and refining, etc.), and examines how many of the big polluters failed or relocated, measured by the change in the number of plants/businesses when an area moved from attainment to non-attainment. Our objective in this paper is to more comprehensively examine the impact of NAAQS non-attainment status on the entrepreneurial activity in a metropolitan statistical area (MSA) by looking at business formations in all industries, not just the location of a targeted few polluters.

Using a 306-MSA panel data set over the 1989-2003 timeframe and controlling for other time-variant confounding effects, such as population growth, per-capita income, tax rate changes, minimum wage rates, energy costs, regional inflation measures, and spatial phenomena (such as, natural disasters) we isolate the effect of non-attainment status on large polluters as well as the linkage industries[v]. We have two measures of entrepreneurial activity, i.e., two dependent variables: business births and net business births (births *minus* deaths). In both cases, we find that non-attainment status for Ozone (O_3) has a significantly negative impact on business births in an MSA. This coefficient, when measured across an average MSA translates into a net loss of 62 businesses. Furthermore, the coefficients on the lagged values of the dependent variable are negative and highly significant. To address the question of how linkage industries and small, locally owned businesses are affected by air quality regulations, we focus on small business births. We find that non-attainment status for O_3 is significant at the 90% confidence level for the small businesses. This result indicates that the direct impact of non-attainment status is more severely felt across small businesses.

The remainder of the paper is organized as follows: Section 2 provides an overview of the EPA air quality regulations and NAAQS, and the existing literature in the area of air quality and economic activity. Section 3 describes the data sources, the determinants of business births and deaths, and specifies the empirical model. Section 4 presents the results. Section 5 summarizes the results and future direction for this research. All tables are in the Appendix section.

Background on EPA regulations and NAAQS

Air quality in all geographical regions of the United States is classified as either in attainment or non-attainment by the EPA. The pollutants for which NAAQS have been established are known as criteria pollutants. Areas that have ambient criteria pollutant concentrations above the NAAQS are considered to be in non-attainment for those pollutants. Areas can be in attainment for some pollutants, while designated as non-attainment for others[vi]. The EPA set NAAQS for pollutants considered detrimental to the public health and the environment. The 1990 CAAA differs from the 1977 Amendments by establishing new non-attainment requirements for three air pollutants common in cities: ground-level O_3, Carbon

Monoxide (CO), and particulate matter less than 10 microns in diameter (PM_{10}). For ground-level O_3, non-attainment areas are categorized into groups of increasing severity designated as marginal, moderate, serious, severe, and extreme. As the severity of the ground level O_3 pollution increases, so do the compliance requirements. Areas designated as marginal, the least severe non-attainment group, must implement a permit program and conduct an inventory of ozone-producing emissions. The more severe classifications must also implement control measures. Control measures must be implemented to reduce emissions of two pollutants known to be precursors to ground-level O_3. These two pollutants are Nitrogen Oxides (NO_x), and volatile organic compounds (VOCs).

For areas that exceed the CO and PM_{10} standards, the two non-attainment classifications are: moderate and serious. Corrective measures required are dependent on the severity of pollution and include the use of oxygenated fuels and/or enhanced emission inspection programs for CO, and implementation of reasonably available control measures (RACM) or best available control measures (BACM) for PM_{10}.

The 1990 Clean Air Act Amendment (CAAA) requires a demonstration of maintenance for ten years after re-designation. To be reclassified from non-attainment to attainment, the CAAA outlines several conditions that must be met, one of which is the development and EPA-approval of a maintenance plan referred to as the state implementation plan (SIP). This plan must specify measures that will be used in the area to maintain compliance with the NAAQS. The plan must include controls the area will employ to ensure emissions remain below certain levels, and contingency measures to ensure prompt correction of any NAAQS violations. Federal funding in various categories, e.g. department of transportation, may be at risk if reasonable progress is not made. For non-attainment counties, new businesses will be subject to more stringent regulations on equipment specifications. Existing businesses face stricter regulations to reduce source emissions and, additionally, new businesses may also be required to purchase offsets from existing businesses (Atkinson and Tietenberg, 1987; Roumasset and Smith, 1990). For O_3, auto-related regulations may be tougher, requiring the state to set up auto emission inspection stations in various parts of the county or state (Henderson, 1996).

In recent years, researchers have provided improved estimates of the benefits associated with the Clean Air Act Amendments (CAAA) by incorporating plant, county and industry fixed effects (Greenstone, 2002). The estimated regulation effects are thus purged of all permanent plant and area characteristics that determine growth. There is evidence that CAAA substantially retarded growth of polluting manufacturers in non-attainment counties. In fact, in the 15 years since the amendments became law, non-attainment counties have lost an estimated 590,000 jobs and \$37 billion in capital stock. However, effects of the CAAA on the concentration of certain pollutants such as SO_X (Greenstone, 2004) and PM10 may not appear conclusively in the absence of a sufficiently spatially-disaggregated analysis. After properly accounting for the spatial heterogeneity within non-attainment counties and incorporating other local area and community characteristics, Aufhammer, Bento and Lowe (2007) were able to show a 7% reduction in ambient PM_{10} concentrations as a result of the 1990 CAAA. In our current analysis, we have chosen to focus only on $O_{3,}$ the justification for which is provided below in section 3.1.

Data Sources and Model Specification

There is a tendency among researchers to concentrate primarily on new business formation in studying entrepreneurship, although the topic is far more multi-dimensional (Acs and Storey, 2004). The existing literature[vii] has identified several factors that appear to be key determinants of new venture formation, covering a range of supply-side, demand-side and policy variables. Based on this earlier work, we have compiled a detailed dataset of key determinants that influence business births and deaths in the United States in order to estimate the impact of federal non-attainment designations for criteria air pollutants on entrepreneurial activity. This section describes our data sources, presents summary statistics, and builds an econometric strategy to estimate the impact of non-attainment designations on entrepreneurial activity.

3.1 The Determinants of Business Births and Deaths

The basic unit of measure in our analysis is the birth or death of a business, measured in each major U.S. metropolitan statistical area (MSA). This data is provided by the U.S. Small Business Administration, Office of Advocacy (USSBA, 2008)[viii]. As the geographies in our analysis are quite varied, ranging from small MSAs such as Bismark, North Dakota or Missoula, Montana with less than 100,000 in total population, to large MSAs such as New York or Los Angeles-Long Beach with more than ten million residents, it is the norm in this literature to normalize the total births or deaths for each geographic area by a measure that represents the size of the local economy. Options for this normalization variable include the total number of businesses, total labor force or total population in the area of concern (Audretsch and Fritsch, 1992; Johnson and Parker, 1994; Keeble and Walker 1994; Campbell and Rogers, 2007; Campbell, *et al*, 2009). In our empirical estimations, we make use of the total number of businesses in an MSA as our normalization variable. Although this method has its critics (Garofoli, 1988), proponents argue that business stock is essential for analysis of firm deaths (Audretsch and Fritsch, 1992).

We chose the total number of businesses as our normalization variable for this paper because it was provided in the same dataset as the total births and total deaths data. Knowing this, we can confidently assume that regardless of any changes to the shape or size of the MSA, both the numerator and the denominator in our dependent variable are calculated using the same urban area from year to year. This would not necessarily be true if we were to use total population or total labor force as the normalization variable – both of these variables come from a different dataset, and therefore may introduce bias in that they may be calculated over a (slightly) different total area. As a robustness check, we have re-run our models using total population as the normalization variable, and the results are virtually identical in sign, significance and general magnitude.

The births (and deaths) in each MSA are further divided into four categories: all births and deaths; births and deaths of businesses with less than 20 employees; births and deaths of businesses with 20 - 499 employees; and births and deaths of businesses with 500 or more employees. The employment size categories are based on the employment size of the parent company – if a business only has 20 employees in a particular MSA but 1,000 in total across the United States, then the business is listed in the 500+ category defined above. This separation allows us to differentiate between a small, locally-owned and operated business, and a small subsidiary of a much larger parent company. We are particularly interested in the small, locally-owned and operated business, which doesn't have the support of a parent company, and which we hypothesize will be more significantly impacted by the local or regional business climate.

The Environmental Protection Agency (EPA) provides non-attainment designation data for each county in the United States in their annual Green Book (EPA, 2008) which summarizes the changes and updates from the Code of Federal Regulations for each of the six pollutants regulated under the NAAQS. Over the 1990-2003 period, four counties (all in the Greater Los Angeles area) were non-attainment for NO_X, 60 counties for SO_2, 141 counties for CO, 107 counties for PM10, and 424 counties for O_3. This list excludes the 8-hour primary standard for O_3 which wasn't regulated until 2004, $PM_{2.5}$ which wasn't regulated until 2005, and lead (for which there were 13 non-attainment counties during the 1990s). In total, 648 of the 3,140 counties in the United States were designated as non-attainment for at least one of the six NAAQS pollutants over the 1990-2003 timeframe. In addition to non-attainment status, the EPA identifies each county listed in the Green Book according to the severity of the non-attainment classification as well as whether the non-attainment county is partial or whole.[ix]

In our empirical models we don't differentiate between the severity of the violation or the partial nature of non-attainment status in any counties. If the county is part of the MSA, and it is non-attainment in any given year, then the MSA within which it falls is identified by a dummy variable that is equal to 1; if it is in attainment for any given year, then that same dummy variable is identified as being equal to zero. The treatment of MSAs which are only partially non-attainment for the NAAQS has been addressed in the literature on environmental regulation. Auffhammer, *et al*. (2009) look at the impact of non-attainment measured at monitors across the United States and find that the air quality improvements are significant when compared to relatively cleaner monitors located in similarly non-attainment counties. This result puts additional emphasis on the treatment of MSAs that only contain a fractional non-attainment area. Maps 1 and 2 in the Appendix present those counties that were (a) continuously non-attainment, (b) non-attainment at some point between 1990 and 2003, and (c) continuously attainment for O_3.

In our analysis, we focus on the non-attainment status for O_3. We chose this pollutant for several reasons: First, it has received the greatest attention in the literature throughout the 1980s and 1990s. Several seminal publications in the economics of environmental regulation literature have focused on it (see: Henderson, 1996). Second, unlike the other NAAQS pollutants which are generally directly emitted and are produced by a relatively smaller sample of industries, O_3 is generated by a number of precursor pollutants that are emitted by a variety of different economic sectors, including residential, commercial and industrial processes, and agricultural operations. Third, O_3 is a secondary pollutant, generated through the interaction of precursor pollutants and sunlight. Because of this, O_3 tends to be more ubiquitous across MSAs' airsheds, unlike the other NAAQS pollutants which have more heterogeneity within an air basin. Fourth, the counties that are non-attainment for O_3 have shown improvements over the years of our study, with a large number of counties moving into and out of attainment. Controlling for the time-invariant MSA-level factors or attributes, this change over time allows for empirical identification of the impacts of non-attainment designations on business births and deaths in each MSA.

A priori, the literature is mixed on the economic impacts of non-attainment. A logical hypothesis would be that non-attainment designation provides a negative incentive for businesses to locate in those MSAs, but studies of the employment impacts of non-attainment would indicate otherwise. For example, Berman & Bui (2001b) find no empirical evidence that heightened environmental standards led to a reduction in the demand for labor in California's South Coast Air Basin. Alternatively, Henderson (1996) found that a switch from attainment to non-attainment led to an exodus of the more severely polluting industries from the non-attainment areas to attainment areas. On the other hand, List and McHone (2000) find evidence that stricter standards could lead to the creation of pollution havens. In order to address these inconsistencies, we turn to the descriptive statistics. Table 2 presents descriptive statistics for the weighted change in the number of businesses, i.e., the net change in number of businesses (business births *minus* business deaths) normalized by the total number of existing businesses in the area, measured across attainment and non-attainment MSAs for O_3, and across all MSAs. On average, across all MSAs, the weighted number of business births minus deaths grew by 1.3% per year throughout the 1990-2003 timeframe. However, when we differentiate by the attainment or non-attainment status of the MSAs, the O_3 non-attainment MSAs have a slightly lower (1.1%) average change than those MSAs that are attainment for O_3. If we lag the assignment of attainment and non-attainment status for each MSA, and look at the weighted change in the net births minus deaths in each MSA, the descriptive statistics tell a different story. For O_3, the non-attainment MSAs experience a -0.11% drop in net business growth in the years following the non-attainment assignment. When we change the unit of measure to small business births and deaths or large business births and deaths only, the negative impact of non-attainment status is not present. However, medium businesses in non-attainment MSAs appear to experience fewer net business births *minus* deaths than their attainment MSA counterparts, on average.

In addition to non-attainment status for ambient air quality standards, several other determinants may influence the births and deaths of businesses. In order to account for these factors, we have collected the most comprehensive and detailed panel of data available for each MSA in the United States over the 1990-2003 time frame. The descriptive statistics for the control variables are presented in Table 2.

From the Bureau of Labor Statistics (BLS), regional consumer price indices (CPIs) were collected (BLS, 2009a). These CPIs were used for two reasons: First, they normalized the explanatory financial variables over time; second, they were introduced directly as a right-hand variable to control for heterogeneity in regional economic recessions or periods of decreased economic activity. The descriptive statistics show that non-attainment MSAs had a larger mean CPI, relative to 1990 levels, than the attainment MSAs. We hypothesize that MSAs that experienced disproportionate increases in their regional CPIs will have less entrepreneurial activity, *ceteris paribus*, than those MSAs with more robust economic climates.

State-level minimum wage and minimum wage change data were collected from the Monthly Labor Review within the BLS (BLS, 2009b). This data was then supplemented with annual Federal minimum wage levels to correct for those states that have minimum wage levels that are below the Federal minimum wage. All else being equal, a higher minimum wage may provide a disincentive for the formation of a new business, or may introduce added costs to existing businesses. On average, the minimum wage in non-attainment MSAs was slightly higher than the minimum wage in attainment MSAs.

State-level sales tax rate data was collected from the CCH Tax Research Network database (CCH, 2009). This variable is intended to act as a proxy for the overall tax climate in a state, and to capture the role that discriminatory taxation plays in retarding entrepreneurial activity in a MSA. We hypothesize that increases in state sales taxes may act as a disincentive for new business formation. Not surprisingly, across all attainment and non-attainment MSAs, the mean sales tax is virtually identical.

Per capita income and population data was collected for each MSA from the BEA's Regional Economic Information System (BEA, 2009) and from the US Census (US Census, 2009) respectively. In the literature, it is common to include population density as an explanatory variable along with population. However, using population density as a measure of urban size was not appropriate for our purposes due to the changes in MSA designations made over time.

Two facts emerge from the preliminary exploratory analysis between population growth and entrepreneurial activity that are worth noting: First, the Pearson correlation coefficient between lagged population growth and our dependent variable is weakly negative. This is true across all entrepreneurial activity, as well as for each of the sub-categories that are based on the size of business starts. Second, MSAs that posted relatively larger population growth experienced weaker or negative changes in business starts. Specifically, measured across all entrepreneurial activity, the average weighted business growth of the bottom three decile groups (i.e., with the lowest lagged population growth totals) is 0.085%; the middle three decile groups is -0.021%, and the top three decile groups (i.e., with the largest lagged population growth totals) is -0.047%. Therefore, we expect that our results will reflect this perverse relationship between population growth and business growth, *ceteris paribus,* and contradict those previous analyses that have shown population growth as a positive influence on entrepreneurial activity.

We hypothesize that income will serve as a deterrent to new business formation. Campbell and Rogers (2007) present results that support this hypothesis. Higher per-capita incomes serve as an opportunity cost for entrepreneurial activity, particularly for smaller businesses, and therefore areas with increases in per-capita incomes should see lower entrepreneurial rates, ceteris paribus. On average, incomes and total population counts are larger in non-attainment MSAs than they are in attainment MSAs.

The average retail price of electricity to commercial and industrial consumers was collected from the Energy Information Administration (EIA 2009). This regional data source provides the average residential, commercial and industrial prices of electricity, per kilowatt-hour. As a large component of the variable cost for many industries, an increase in electricity prices will act as a disincentive for entrepreneurial activity. In our empirical models, we use the industrial and commercial electricity rates, but it is worth noting that all three measures are highly correlated (the Pearson correlation coefficient ranges from 0.96 to 0.90 across the three measures). The electricity rate is considerably higher in non-attainment MSAs than in attainment MSAs – on the order of $0.60 - $0.90 per kilowatt-hour.

An index of economic freedom – collected from the Economic Freedom Index of North America (Karabegovic, *et al*., 2003, 2005) – was included to account for state-level barriers to new business formation. The index itself is constructed from ten individual measures which fall into three broad categories: the freedom of the labor market, takings and discriminatory taxation, and the size of state government. The index is based on a 10-point scale, with 0 being no economic freedom and 10 indicating a high degree of economic freedom. Previous research has shown that economic freedom has a positive influence on entrepreneurial activity (Campbell and Rogers, 2007; Campbell, *et al*., 2009).

Loans and Leases data was collected from the Federal Deposit Insurance Corporation's Historical Statistics on Banking Commercial Bank Reports (FDIC, 2009). This data measures the lending and leasing total for the previous period for each state. We hypothesize that increased availability of lease and loan funds will make starting a new business easier, and will allow troubled businesses to remain solvent.

Since MSA-level unemployment statistics aren't available for our entire sample period, we collected the annual county-level labor force and unemployment levels (totals) for each county in the U.S. between 1990 and 2007 from the Bureau of Labor Statistics (2009b). These county totals were then aggregated up to the MSA level, and an annual unemployment rate was calculated for each MSA. We utilize the change in the unemployment rate as an explanatory variable in all of our models.

Finally, information on natural disasters was collected from the United States Geological Survey (2009) and from the National Oceanic and Atmospheric Administration (2009). This dataset includes all major natural disasters over time, including hurricanes, floods, earthquakes and tornadoes, and is presented as a binary variable for each MSA-year in the dataset. Approximately 5% of MSAs experienced a major natural disaster in any given year, and not surprisingly, this probability is uniform across both the attainment and the non-attainment MSAs.

3.2 Specification of the Econometric model

In this section we link the variables discussed in Section 3.1 to the measures of the weighted changes in business births and deaths in order to explain the determinants of the changes in the spatial distribution of entrepreneurial activity in United States metropolitan statistical areas between 1990 and 2003. Specifically, we employ an Arellano-Bond (1991) generalized method of moments estimator for panel data analysis. Because new businesses are much more likely to fold in subsequent years due to poor management or due to a miscalculation of the robustness of the market within which they have entered, our empirical specification requires that lags of the dependent variable be introduced as explanatory variables.[x] The inclusion of lagged values of the dependent variable introduces an endogeneity concern, and the Arellano-Bond estimation allows us to estimate these models that lack strict exogeneity in the explanatory variables.

In our empirical models, the weighted change in the number of business (births minus deaths) is explained by lagged changes in five major groups of variables: county-specific environmental regulation, MSA-specific socioeconomic trends; region-specific inflationary pressures and energy prices; state-specific economic trends, and lagged values of the dependent variable itself.

Our measure of entrepreneurial growth (net business births *minus* deaths), when weighted by the total number of businesses in a MSA, is: $E_i^t = \left(\left(BB_i^t - BD_i^t\right)/TB_i^{t-1}\right)$, for each MSA *i*, in each year *t*. In this equation *E* equals our constructed measure of entrepreneurial activity, *BB* measures the number of business births, *BD* measures the number of business deaths, and *TB* measures the total number of businesses in operation. Our basic econometric model is therefore equation (3.1):

$$E_i^t = \alpha_1 E_i^{t-1} + \alpha_2 E_i^{t-2} + \alpha_3 E_i^{t-3} + NA_j^{t-1}\omega + \boldsymbol{X}_i^{t-1}\beta + R_k^{t-1}\theta + \boldsymbol{P}_l^{t-1}\varphi + \delta_i + \lambda^{t-1} + \eta_i^t \qquad (3.1)$$

where E_i^{t-x} are a series of lagged measures of the dependent variable. NA_j is a vector of dummy variables that represent the average treatment effect of non-attainment status in county *j* on MSA *i*. $\boldsymbol{X}_i$ is a vector of controls that are measured at the MSA level, which includes the per-capita income, total population, and any natural disaster events that have occurred in MSA *i*. R_k is a vector of controls that are measured at the state level, *k*. These state-level controls include state sales tax rates, an index of economic freedom, commercial loans and leases data, and the state minimum wage. P_l is a vector of controls that are measured at the multi-state regional level, *l*. The regional control variables include the commercial and industrial electricity rates, and the regional consumer price index. We include year fixed effects (λ), MSA fixed effects (δ_i), and η_i is the idiosyncratic unobserved error component.

In order to remove any time-invariant characteristics that are unobservable for each MSA, we estimate model (3.1) in first-differences, which removes the MSA fixed effects in estimation (Holtz-Eakin, *et al*., 1988).[xi] Our equation to be estimated is presented below in model (3.2):

$$\Delta E_i^t = \alpha_1 \Delta E_i^{t-1} + \alpha_2 \Delta E_i^{t-2} + \alpha_3 \Delta E_i^{t-3} + \Delta NA_j^{t-1}\omega + \Delta \boldsymbol{X}_i^{t-1}\beta + \Delta R_k^{t-1}\theta + \Delta \boldsymbol{P}_l^{t-1}\varphi + \lambda^{t-1} + \Delta \eta_i^t \qquad (3.2)$$

All changes in the right-hand regressors are introduced with a single-year lag.[xii] Our dependent variable, ΔE_i^t, is represented by four different permutations: first, we measure entrepreneurial activity of any size; next, we restrict the sample of business used to calculate the entrepreneurial activity measure to only small facilities only (less than 20 employees), medium-sized facilities only (20 - 499 employees), or large facilities only (500 or more employees).

Results

Table 3 presents the empirical results from the estimation of the econometric models outlined in Section 3. We remind the reader that the dependent variable in these estimations, *entrepreneurial activity*, is the weighted change in the net number of businesses, i.e., [births – deaths] in an MSA normalized by the total number of businesses in a given year. Models (1) – (4) provide estimates for equation (3.2), with the dependent variable represented by total entrepreneurial activity, as well as entrepreneurial activity measured across small, medium and large businesses, respectively. In all models, we control for changes in other NAAQS attainment status, as well as year fixed effects.

In model (1) we show that non-attainment status for O_3, the variable of interest, has a significantly negative impact on net business growth in an MSA. The mean impact is a 0.417% reduction in the entrepreneurial activity of an average MSA. This coefficient, when measured across an average MSA (with an annual net growth rate of 1.3% and 14,820 total businesses) translates into a net loss of 62 businesses in a single year following the non-attainment designation. The coefficients on the lagged values of the dependent variable are negative and highly significant. Not surprisingly, growth in previous periods has a negative impact on current growth which corresponds with the findings of Campbell, *et al.* (2009). This negative effect diminishes as the time lag increases. Similarly, per-capita income and industrial energy rates have negative and significant impacts on entrepreneurial activity, as does population growth, which our preliminary exploratory analyses of the data had already suggested. Conversely, economic freedom and the availability of funding through loans and leases have a significantly positive effect on entrepreneurial activity.

Model (2) presents the results of non-attainment status when regressed on net business growth of small businesses. Consistent with Model (1), non-attainment status for O_3 is significant at the 1% level, and is similar in magnitude. The mean impact is a 0.373% reduction in the entrepreneurial activity of small businesses in an average MSA. This coefficient, when measured across an average MSA (with ~10,193 total small businesses) translates into a net loss of 38 small businesses out of a total loss of 62 businesses. Like Model (1), growth in previous periods has a negative impact on current growth of small businesses, and this negative effect diminishes as the distance between time periods increases. As in Model (1), per-capita income, industrial energy rates and population growth all have negative and significant impacts on entrepreneurial activity. However, economic freedom, which reflected a large, significant impact when measured across all businesses, isn't significant when measured across small businesses. The availability of funding through loans and leases has a positive and highly significant effect on entrepreneurial activity for small businesses.

Models (3) and (4) present the results of non-attainment status when regressed on net business growth of medium and large-sized businesses, respectively. Individually, these two categories of business sizes comprise approximately 15% of the total number of businesses (with small businesses making up the remaining 70%). There are several points worth noting in the results from these estimations. First, the coefficient estimates for O_3 non-attainment are small and generally not significant. For medium-sized businesses, the coefficient for O_3 is positive and marginally significant at the 10% level, and translates to an increase of 14 medium-sized businesses. On the outset, this number might seem small but the overall impact is not necessarily marginal. For instance, if these medium-sized businesses employ on the upper cut-off for the medium category (i.e., up to 499 people), then 14 business losses could translate to approximately 7,000 employees affected. Clearly, this has substantial policy implications. Second, the industrial energy rate has a significantly large, negative impact on large business, and the commercial energy rate has a significant but small negative impact on medium businesses. For large businesses, a one standard deviation increase in the rate per 100 kWh translates into a loss of 40 large businesses in an average MSA. Further, our results indicate that the change in unemployment rate has a positive, albeit insignificant, effect on new business growth. We note that the magnitude of the coefficient is particularly large for small business formation. Occurrences of major catastrophes have a negative and marginally significant impact on large firms.

Thus far, our models have focused on business births and deaths in tandem, in order to measure the net effect of outside pressures on overall entrepreneurial activities. The literature has noted that business births and deaths are highly persistent – any models that analyze business births must include data on business deaths, and vice versa (Johnson and Parker, 1994, 1996). In order to attempt to disentangle the individual roles that births and deaths play in the overall change in entrepreneurial activity, we present a series of deconstructed models. For simplicity, we constrain our estimations to all firms, and small firms. Specifically, we estimate equation (3.2), but in place of ΔE_i^t as the dependent variable, we use the weighted change in business births or deaths individually (i.e., $E_i^t = BB_i^t / TB_i^{t-1}$ for the births equation, or $E_i^t = BD_i^t / TB_i^{t-1}$ for the deaths equation). We include three lags of both the dependent variable and the weighted (but omitted) births or deaths component from equation (3.2) as explanatory variables.

Models (1) - (4) in Table 4 present the results of the GMM estimations of the change in weighted births and weighted deaths for all businesses and small businesses. With the exception of the additional weighted lags of the opposite growth measure for each equation (i.e., weighted births as an explanatory variable for the weighted deaths equation, and vice versa) the models are identical to those presented in Table 3, and include the same selection of explanatory variables.

For simplicity, we only present the new regressors and the coefficients of concern, or those that we focused on in our discussion of Table 3. It is worth noting, however, that the lagged values of the dependent variable in all four models are virtually identical in relative magnitude, sign, and significance to those presented in Table 3. Of all the lagged values of the opposite growth measures, only the lagged birth variables are significant in explaining the weighted change in business deaths.[xiii] This is not surprising: The literature notes that young businesses are much less likely to succeed, and therefore areas that experience a growth in business births in early periods would be expected to have elevated rates of business deaths in later periods, *ceteris paribus*. Similarly, there is no reason to expect business deaths to stimulate business growth in the subsequent period. Our results confirm this.

The coefficient of concern, the impact of non-attainment, is negative and significant for business births, and positive and relatively significant for business deaths. The impact of a non-attainment designation is -34 total businesses births, and -38 small businesses births, when measured across an average MSA (with an annual net growth rate of 1.3% and 14,820 total businesses). Similarly, a non-attainment designation results in an increase of 30 total business deaths. Taken together, the reduction in business births and increase in business deaths is virtually identical to the results presented in Model (1) of Table 3.

All of the coefficient estimates on the other explanatory variable are consistent with the results presented in Table 3. When significant, all of the factors that have been identified as having a negative impact on net entrepreneurial activity have a negative sign when measured against business births, and a positive sign when measured against business deaths. Specifically, increases in per-capita income, industrial energy rates, or population totals all have a negative impact on business births and a positive impact on business deaths. Surprisingly, the presence of loan and lease funding is not significant in explaining business births, but a lack of loan and lease funding is significant in explaining business deaths. This finding is interesting insofar as it reveals that additional funding availability acts to retard the dissolution of struggling businesses as opposed to creating opportunities for new businesses.

One other note worthy finding is that economic freedom has a negative and marginally significant impact on deaths (all) but not on births or net births. This result is expected given that in a non-regulated economic environment, firms are allowed to fail. As Campbell, *et al*. (2009) explain: "Economic freedom as defined tends to be rather synonymous with non-intrusive government that generally does not intervene into the market. For the potential entrepreneur, that means state government will not block or hinder one's launch of a new business. However, that also means that the government will not intervene to help keep a venture afloat. Entrepreneurs who launch ventures in these states are fully exposed to Schumpeter's gales of creative destruction".

Conclusions

The assertion that regulation matters is a logical one but over the years studies on air quality regulation have found that local regulation has little or in some cases perverse effects on firm location decisions (McConnell and Schwab, 1990; Bartik, 1988). Panel estimation addresses the cross-sectional correlation that could lead to such counter-intuitive results but even with panel estimation methods, researchers have failed to show a negative association between environmental regulation and industrial activity (Henderson, 1996; Levinson, 1996; Becker and Henderson, 2000, 2001). Using two different measures of entrepreneurial activity (i.e., normalized business births and normalized births *minus* deaths) we are able to show that non-attainment status for O_3 has a significantly negative impact on business births in an MSA.

Overall, our results are consistent with expectations: Non-attainment status for O_3 in a given year causes a reduction in the number of new business births in the subsequent year as some existing businesses struggle to implement the required changes and new businesses anticipate or face stricter regulations. Growth in previous periods has a negative impact on current growth which corresponds with the literature, and this effect diminishes as the time lag increases. Economic freedom and the availability of funding through loans and leases have a significantly positive effect on entrepreneurial activity while increases in per-capita income, energy rates and population tend to deter it.

We also show that the impact of non-attainment status on net business growth varies depending on the size of the businesses, with the most pronounced effect being on smaller businesses. The impact on medium businesses seems marginal in comparison; however, a loss of 14 medium businesses could have a substantial impact by affecting up to 7,000 employees in an average MSA. The availability of funding through loans and leases has a positive and highly significant effect on entrepreneurial activity for small businesses. However, economic freedom, which reflected a large, significant impact when measured across all businesses, isn't significant when measured across small businesses. Although insignificant, the change in unemployment rate has a positive effect on new business growth, with the effect being particularly large for small business formation. Our findings have certain policy implications: The smaller businesses – the mom-and-pops – are the ones that bear the brunt of non-attainment status designation. Mid-size businesses could be substantially impacted by air quality regulations as well. Larger businesses, however, are only marginally affected by the non-attainment status. This is an important result, because entrepreneurial activity typically starts off small. If these are the types of businesses that are negatively affected by stringent air quality standards, then we anticipate long-run implications for entrepreneurship in general. As for the overall business environment, greater economic freedom leads to the creation of more businesses (medium-sized). Therefore, state and local governments need to consider policy options that offer more economic freedom – as measured by an increase in the freedom index – in order to be consistent with their growth and development goals.

Although substantial research has been done on air quality and location of manufacturing plants/firms, the relationship between air quality regulation and its impact on new business formation is relatively unexplored. We believe that our current paper provides important insights into that relationship. In future extensions of this work, we will examine the spillover effects of MSA non-attainment status, and subsequently test the hypothesis regarding the creation of pollution havens. In enhancing the explanatory power of our current model, we will include some additional demand-side (age distribution of population) and supply-side (educational attainment) variables to shed more light on the quality and composition of the entrepreneurial resource pool.

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[i] According to the EKC hypothesis, continued economic growth, while initially damaging to the environment, eventually leads to superior environmental quality.
[ii] See Herzog and Schlottman (1991) for a review.
[iii] Pollution havens are created when new pollution intensive plants are diverted to counties with less stringent environmental regulations, whereby counties historically free of pollution become havens for polluters.
[iv] McConnell and Schwab (1990), Henderson (1996) and Becker and Henderson (2000, 2001) use non-attainment status for Ozone only, not any other pollutants.
[v] Focusing on MSA-level instead of state-level characteristics addresses criticism of earlier studies that rely on measures of regulation that are too aggregated (Jaffe, *et al*., 1995).
[vi] Some areas are designated as "maintenance" areas. These are regions that were initially designated as non-attainment or unclassifiable and have since attained compliance with the NAAQS.
[vii] Keeble, *et al*., 1993; Reynolds, 1994; Sutaria and Hicks, 2004; Karabegovic, *et al*., 2003, 2005; Campbell and Rogers, 2007; Campbell, *et al*. 2009.
[viii] It is worth noting that the MSA boundaries are based on their 2002 definitions, and the business birth and death data attributed to them is measured from March of the beginning year to March of the ending year, and excludes any establishments without any first-year employees. This definition year is important, because we are unable to account for any inclusions, splits, or exclusions in the data over time. The Department of Commerce has identified those MSAs that underwent significant changes. We have tested the for significance of these changes empirically, and didn't find that this led to a significant change in our results. For a more detailed discussion of the business birth and death dataset, please see "Statistics of U.S. Businesses – Microdata and Tables" from the Small Business Administration (Armington, 1998).
[ix] Of all of the NAAQS pollutants, O_3 has the greatest number of severity classifications, including transitional, marginal, moderate, serious, severe and extreme, each associated with a higher ambient concentration and each classification bringing with it more serious penalties for non-attainment.
[x] This practice is common in the literature – see Johnson and Parker, 1996, Campbell *et al*. 2009, Keeble and Walker, 1994).

[xi] It is worth noting that most of the time-invariant spatial factors that may exert an influence on entrepreneurial activity, such as proximity to airports, marine ports, rail yards, tourism areas, major research colleges, etc., are excluded when we take first differences. We leave the process of regressing the residuals on these time invariant characteristics for future work.

[xii] By single-year, we mean that the impact of a change in non-attainment designation assigned in November of 1994 would be regressed on the change in entrepreneurial activity measured from March of 1995 through March of 1996.
[xiii] The magnitude of the influence of the lagged change in weighted births for all businesses and small businesses diminishes with time, as does the significance of the coefficient.