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Environmental Regulations and Economic Performance:

Evidence from Ozone Attainment Status

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Abstract

In this paper, we seek to identify whether there are differentiating economic and spatial characteristics across counties that have achieved the ozone air quality standard and those that have not. Counties are categorized based on their metropolitan and ozone standard attainment status for the 1990 –1998 study period and differences in mean values of per capita personal income (*PCPI*), wage per worker (*WPW*), and manufacturing and service sector productivity are detected. For per capita personal income (*PCPI*) and wage per worker (*WPW*) we find higher mean values in long-term non-attainment areas than in long-term attainment areas. When we calculate measures of manufacturing and service sector productivity, however, we find the opposite result; that long-term attainment areas have a higher mean value than long-term non-attainment areas.

We also use an ordered probit model to examine the determinants of attainment status. Taking advantage of regulatory changes in the 1990 Clean Air Act Amendments, we use a richer proxy for regulatory intensity than has previously been available to researchers. Studies that examine county non-attainment status prior to 1990 could only rely upon a binary attainment variable (*i.e.*, either an area was in attainment or not). Our probit results show that a 10 percent increase in the natural log of population density (*LN POPDENS*) decreases the likelihood that a county will achieve the ozone standard by 7 to 10 percent. When only metropolitan counties are considered, increases in manufacturing share (*MFGSH*) decrease the probability of attaining the ozone standard by 30 to 50 percent.

1. Introduction

It remains an open question what kind of effect air quality regulations have on a location's economic performance. The U.S. has achieved remarkable improvement in air quality since the passage of the Clean Air Act in 1970, but the economic impact of increased control of air pollution on metropolitan and county economies is not clear. There is a substantial body of literature devoted to the quantification of the benefits and costs of the Clean Air Act and from this work, we have learned about the estimated costs of complying with air regulations and the positive benefits derived from non-market goods (such as improvements in respiratory health of people due to reduced exposure to air pollution). However, we still know little about the overall composition and economic performance of the areas affected by air pollution regulations. Are there patterns to suggest that areas subject to air quality standards are less likely to prosper under the burden of regulation? To this end, we identify differentiating economic and spatial characteristics across counties that have achieved the ozone air quality standard and those that have not. We use statistical and econometric techniques to test whether or not compliance with the ozone standard affects economic performance of counties with similar characteristics. If no discernible relationship exists between economic and regulatory variables, the standard's effect on economic performance may be neutral which, some may argue, is the desired outcome for government policy.

Numerous studies have recently examined how air quality regulations affect U.S. manufacturing and economic productivity (Becker and Henderson, 1999; Bartik, 1998; Gray, 1997; Levinson, 1996; Duffy-Deno, 1992). Typically, industry-specific regulations are analyzed at the firm level, showing how firm costs and/or productivity are affected by specific rules. For the National Ambient Air Quality Standards (NAAQS), and in particular for this study, the ozone air quality standard, it is more difficult to assess direct and/or indirect effects of an area's air quality status on economic productivity. This, in part, may be due to the broad applicability of the NAAQS across the entire U.S. Existing work generally hypothesizes that the regulations imposed when a county fails to meet an air quality standard may negatively affect firm location, investment decisions, or productivity levels. However, a full analysis of the economic impact of air quality standards must extend beyond the firms and industries directly affected by air pollution regulations and move into the territory of possible indirect and unaccounted effects, or externalities (either positive or negative).

Some studies have found that attainment status may affect firm location and investment decisions in certain manufacturing industries (Becker and Henderson, 1999; Becker, 1997). Becker and Henderson used attainment status as the dependent variable in a probit model to estimate firms' propensities to invest and locate in non-attainment areas. Similarly, Gray (1997) and Gray and Shadbegian (1993) found that manufacturing plant location and business investment decisions are adversely affected by the stringency of air quality regulations at state and local levels using multinomial logit estimation techniques. Others, however, find weak or mixed evidence to support the theory that environmental regulations impact new plant location or regional manufacturing activity (Levinson, 1996; Duffy-Deny, 1992; Bartik, 1988). With the exception of the work by Becker (1997) and Becker and Henderson (1999) who use county level data, the spatial unit of analysis for the rest of the studies is the local, state, or regional level. Using broader spatial units may make it more difficult to control for other location-specific characteristics that may be correlated with regulatory variables. Nevertheless, most of the studies take advantage of a detailed proprietary database, the Longitudinal Research Database (LRD), which enables researchers to track firm investments and location decisions over time.

This provides a richness in the data that is not available in publicly provided data, where firm characteristics are aggregated within the spatial unit *i.e.*, metropolitan area, county, state, or nation.

In addition to estimating the effects of regulations on firm activity and location choices, estimating the economic costs of regulations is an equally active area of research. Porter (1991) and Porter and van der Linde (1995) argue that the costs associated with meeting environmental regulations may be outweighed by the innovations in production processes that result when these regulations are put in place. Still, others disagree (Palmer *et al.*, 1995) and cite annual expenditures on environmental protection of $100 billion net any estimable offsets. Jaffe and Palmer (1997) use panel data to test Porter's hypothesis and find lagged compliance costs have a positive effect on research and development (R&D) expenditures. They do not find that the increased R&D expenditures translate into innovative output. Taken as a whole, this body of literature provides no clear answer to the question of how the economic health of the U.S. is affected by air pollution regulation.

These examinations of the effects of air pollution regulations on the manufacturing industry tell only a partial story because the air quality standards are designed to *improve ambient air quality in a specific area* rather than *reduce emissions at a particular source.* Acknowledging that the impacts of these standards are location-specific, we seek to identify possible impacts of the ozone air quality standard on various sectors of the economy in addition to manufacturing. This is important in the context of the debate concerning the impact of regulations on economic performance, but also in broader terms as the U.S. economy shows signs of shifting to a more service-oriented economy. Broadening the scope of this analysis allows for a more comprehensive evaluation of the relative effects of the ozone air quality standard.

We begin to look at these overall effects of the ozone standard by using variables that represent county-level income and wages. We partition these variables according to regulatory and metropolitan characteristics to assess if any differences exist in these indicators for counties that attain the ozone standard and those that do not. These spatial taxonomies allow us to follow counties with similar environmental and urbanization characteristics through time and determine if there are discernable trends within the ozone attainment and/or non-attainment areas. Controlling for metropolitan status and population density, the results show significantly higher wages and income in counties that do not achieve the ozone standard. This leads us to consider possible factors that may explain why this occurred. We hypothesize that those counties not achieving the ozone standard will vary both in the composition of firms and sectors operating there and will have significantly different spatial characteristics, especially in terms of the intensity of economic activity.

We use an ordered probit model to consider what, if any, characteristics would make it less likely for a county to meet the ozone air quality standard. It is plausible that the representation of certain sectors and the population and manufacturing densities of a county (as proxies of the intensity of economic activity) would be important determinants of a county's attainment status. Taking advantage of regulatory changes in the 1990 Amendments to the Clean Air Act, we use a richer proxy for regulatory intensity than has previously been available to researchers. Typically, the attainment variable was binary (*i.e.*, either an area was in attainment or not), but beginning in 1990, county-level attainment designations varied in their intensity of application. Those areas that do not attain the ozone air quality standard are now classified by their severity of noncompliance. These classifications act as a signal to air quality officials that ozone levels are exceeding the standard set by EPA. The non-attainment area classifications are: *marginal*, *moderate*, *serious*, *severe*, and *extreme*, with extreme being the classification set aside for the areas that are most out of compliance with the ozone standard (Clean Air Act Amendments of 1990, Section 185(a)). Regulatory requirements placed on non-attainment areas are more stringent as areas are further from the air quality standard level. We used these classifications to create six values, each representing a different level of non-attainment.

This introduction serves as the first section of our paper. Section 2 lays out the background for the ozone air quality standard and describes how non-attainment status is designated. Section 3 explains our newly developed taxonomies while Section 4 describes our dataset and variables. Section 5 discusses the statistical findings and Section 6 describes the econometric results from our ordered probit model. Section 7 concludes by offering directions for future research.

2. Ozone Air Quality Standards and Non-attainment Areas

As mandated by Congress in the Clean Air Act (CAA, Section 109(a)(1)), the U.S. Environmental Protection Agency established National Ambient Air Quality Standards (NAAQS) to achieve and maintain a certain level of air quality throughout the United States. One of the six criteria pollutants for which the NAAQS has been set is ozone, a photochemical oxidant that is a major component of smog. Ozone results from complex chemical reactions between volatile organic compounds (VOCs) and nitrogen oxides (NOx) in the presence of sunlight and is known to cause a number of health problems associated with respiratory function.

The standard for ozone specifies a maximum concentration above which there may be adverse effects on human health. The threshold value for ozone has been set at 0.12 parts per million (ppm), measured as a 1-hour average concentration. An area meets the standard if the highest hourly value does not exceed this 0.12 ppm threshold more than one day a year. If an area does not meet this standard, it may be designated a non-attainment area through a formal rule-making process. An area is considered in attainment if it meets the ozone air quality standard for three consecutive years.

Since 1990, ozone non-attainment areas have been further classified by the severity of their noncompliance with the ozone standard. The further a non-attainment area is from meeting the ozone standard, the more stringent are the requirements it must meet as it works towards attainment status. The ozone non-attainment area classifications as they appear in the Clean Air Act Amendments of 1990 (Section 181(a)) are detailed in Table 1.

[Table 1 Here]

If a State contains a non-attainment area, it is required to submit a State Implementation Plan (SIP) that describes how and when the area will be brought into attainment (CAA, Section 172(c)(1)). SIPs must also describe how states plan to make reasonable progress towards attainment by limiting the emissions of both VOCs and NOx (CAA, Section 172(c)(2)). In other words, States must show their non-attainment areas are working towards compliance with the standard before they approach their deadlines.

Depending on whether stationary pollution sources are new or existing, they face different requirements when located in non-attainment areas. Once an area is designated as non-attainment, existing sources located there must adopt “reasonably available control technologies”

(RACT) as expeditiously as practicable. Requirements for existing sources are not as stringent as they are for new stationary sources that plan to locate in non-attainment areas.

New stationary sources locating in non-attainment areas must obtain pre-construction permits and undergo New Source Review (NSR). To obtain a construction permit, new sources must demonstrate that they will not negatively impact a non-attainment area's ability to attain the ozone standard by its target date. They do this by purchasing VOC or NOx offsets, which are credits created when existing sources reduce their emissions of these pollutants. New sources must also demonstrate the ability to achieve the "lowest achievable emissions rate" (LAER). LAER is the most stringent emissions limitation in a SIP, or alternatively is the most stringent level of pollution control achievable in the related industry group. In attainment areas, new sources are subject to Prevention of Significant Deterioration (PSD) regulations (CAA, Section 161). PSD regulations require new sources to adopt the best available control technology (BACT), a lower standard than LAER, and to obtain pre-construction permits. In general, new sources in non-attainment areas are subject to stricter requirements regarding air pollution control than new sources in attainment areas.

As stated earlier, the more an area is out of compliance, the stricter are the requirements on the sources in that area. For example, the definition of "major source" (*i.e.*, a source required to comply with the NSR regulations) differs across ozone non-attainment areas based on their classification. A larger number of sources are included in the definition of new source as the classification of the area is worse. This requires a larger proportion of sources in an area to take action to limit emissions of the ozone precursors VOCs and NOx. Any source that has the potential to emit the following amounts of VOCs or NOx combined is considered "major:"

- greater than 10 tons per year (tpy) in extreme non-attainment areas;
- greater than 25 tpy in severe non-attainment areas;

- greater than 50 tpy in serious non-attainment areas; and
- greater than 100 tpy in marginal or moderate non-attainment areas.

Besides the definition of a major source, the number of mandates on non-attainment areas and their stringency also differs based on classification (CAA, Section 182). For example, existing sources in *marginal* non-attainment areas only have to ensure they are meeting RACT requirements for VOCs and new sources must go through New Source Review. Sources in *moderate* non-attainment areas must comply with the above, but must also meet additional requirements including the adoption of RACT to control NOx emissions. Sources in *serious* non-attainment areas must go several steps further by formulating a plan for 3 percent annual average reductions in ozone precursors until the area is considered in attainment, modeling a demonstration of attainment of the standard, adopting a clean fuels program (if applicable), and adopting an enhanced monitoring plan among other requirements.

3. Spatial and Economic Taxonomies

County-level economic data is broken down into two different taxonomies according to attainment and metropolitan characteristics. Another sectoral taxonomy further deconstructs the composition of each county economy.

3.1 Attainment and Non-Attainment

We partition counties into categories with similar attainment characteristics to isolate those factors that may be associated with the ozone air quality standard (conveniently, we also capture a rough proxy for air quality in the attainment variable, indicated by ozone levels, for these areas). The attainment taxonomy assigns a county a long-term attainment (*LT ATT*) designation if the county was in attainment of the ozone air quality standard during the entire

1990-1998 study period. A long-term non-attainment (*LT NON-ATT*) designation is made if EPA determined the county was not in attainment (at any intensity level) during the period. There were 265 such counties and these form the basis for our analysis.

If a non-attainment county moved into the attainment classification before 1995, it received a short-term non-attainment (*ST NON-ATT*) designation. Only one county moved from attainment to non-attainment status over the study period, while 125 counties moved from non-attainment to attainment after 1994, thus providing evidence of the general improvement of air quality in the 1990s, as it relates to ozone.

3.2 Metropolitan and Non-Metropolitan

Metropolitan definitions are dynamic since counties that comprise a metropolitan area may change over time. To control for the dynamic nature of metropolitan definitions, we assign metropolitan status to counties according to time-variant definitions of Metropolitan Statistical Areas (MSAs)[1] determined by the Office of Management and Budget (OMB). Long and Nucci (1995) discuss the significance of recognizing the dynamic nature of metropolitan classification and show that metropolitan population growth is primarily a result of annexation of counties rather than demographic shifts towards urban areas. In addition, these authors make explicit the argument that assigning the metropolitan status of counties based on current definitions is highly problematic. For example, in our dataset there were 98 counties that moved from non-metropolitan to metropolitan status in 1994 or later. Failure to use an appropriately dynamic spatial taxonomy would designate these counties as metropolitan for the entire study period thereby biasing the results.

It is important to track the dynamic definition of MSAs for two reasons. First, metropolitan areas benefit from agglomeration externalities and knowledge spillovers (Becker *et al.*, 1999) that create distinctively different economic conditions (Sveikauskas, 1975; Glaeser *et al.*, 1995). Second, to the extent that metropolitan status is a result of increased investment by the private sector, expanding infrastructure, and/or increased road travel, we are interested in tracking air quality trends across metropolitan categories. If OMB designated a county as a component of a metropolitan statistical area in the 1990, 1993, and 1999 published definitions, we designated the county as long-term metropolitan (*LT METRO*). Similarly, for counties that were not included as a component of a metropolitan area in the three published definitions, the county was assigned long-term non-metropolitan (*LT NON-METRO*) status. Those areas that were non-metropolitan according to the 1990 definition and became metropolitan in the 1993 definition are classified as new metropolitan (*NEW METRO*). The two counties that became metropolitan in 1999 are considered *(LT NON-METRO)* since they still were not designated metropolitan at the end of the study period, 1998.

<u>3.3 Sectoral Taxonomy</u>

A taxonomy of industrial sectors is used to develop variables representing the proportion of sectoral wage shares for each county. Traditionally, industry groups are divided into primary (agriculture, forestry, fisheries, and mining), secondary (manufacturing and construction), and tertiary (distribution and services) categories, but here we borrow from international trade theory (Krugman, 1980) and distinguish between *traded* and *non-traded* goods and services. Henderson (1988) extended this notion to regional or metropolitan economies and showed that 50 to 60

[1] MSA designation is based on two criteria: (1) a city of 50,000 or more population, or (2) an area of 50,000 or more population, provided that the component county/counties of the metropolitan statistical area have a total population

percent of metropolitan output falls into the traded category for U.S. metropolitan areas. In the simplest sense, metropolitan areas are an aggregation of adjacent counties or a single county that meets the criteria of a metropolitan area. As the building blocks of metropolitan counties, we argue that county economies can also be partitioned according to the *traded* and *non-traded* dichotomy.

Traded goods and services can be exports or imports of a metropolitan economy, while non-traded goods and services are normally produced and consumed locally. Non-traded goods and services are not subject to competition from outside the metropolitan area. Examples of tradable goods and services include the manufacture of textiles, automobiles, computers, air transportation, and banking and legal services. Non-traded goods and services include construction, electric and gas utilities, retail trade, personal and social services, and government and local passenger transportation. Tradable goods and services tend to drive economies while non-traded goods and services are those that support the population and the trading sectors.

Following Drennan (1999) and Drennan *et al.* (2001), we choose to focus on the wage shares from the "traded" side of the economy and derive shares from the *Primary (PRM), Distribution (DIST),* and *Manufacturing (MFG)* sectors, as well as a broad class of service sectors referred to as Information Services (see Appendix A for a list of SIC codes within each category). Information Services is broken down into producer and consumer services and includes *Financial Producer Services (PSFIN)* (banking, securities, insurance, and real estate), *Other Producer Services (PSOTH)* (communication, business, professional and legal services), and *Advanced Consumer Services (ACS)* (health services, entertainment, and educational services).

of at least 100,000.

4. Economic and Environmental Performance Measures

We use data from several sources for our economic variables. The Regional Economic Information System (REIS) database (Bureau of Economic Analysis 1998, U.S. Department of Commerce, Washington D.C.) provides data for Per Capita Personal Income (PCPI) at the county level.[2] PCPI (in 1996 chain-weighted dollars) is a population-weighted average of total county earnings and non-wage income. It serves as a useful proxy for the overall performance of a county's economy because it captures all wage and non-wage income, which could be in the form of interest, dividends, or pensions. In other words, PCPI captures income that is not location specific. A variable *REL PCPI* was created by taking the ratio of each county's PCPI to national average PCPI. REIS population estimates were used to create the variable *POPDENS*, which is simply total county population divided by total county area in 1990.

Yearly estimates for Non-Farm Employment (*NFEMP*), Manufacturing Employment (*MFGEMP*), and Non-Farm Earnings (*NFEARN)* were also collected from REIS. *NFEMP* estimates employment for persons not engaged primarily in agricultural activity. Similarly, *NFEARN* excludes earnings derived by the agricultural sector. By excluding agricultural employment and earnings we more accurately estimate the non-farm sectoral composition of a county's economy. This is particularly important for our analysis since agricultural activity results in relatively low levels of ozone, and therefore is, in large part, ancillary to the ozone standard. Wage per worker (*NFWPW*) was calculated by dividing *NFEARN* by *NFEMP*.

The Bureau of the Census annually publishes the County Business Patterns (1990-1998) from which we collect the number of manufacturing establishments in each county. We created the variable Manufacturing Density (*MFGDENS*) by dividing the number of manufacturing establishments in a county by the number of square miles in that county in 1990.

Each sector's share of economic activity was calculated by dividing REIS estimates of county earnings in that sector by total county earnings. Consistent with findings of Henderson (1988), the shares of manufacturing, distribution, advanced consumer services, and producer services capture just over 50 percent of county economic activity and since they represent the *traded* goods and services, they arguably represent the sectors that at least partially drive the development of the economy. We acknowledge it is unlikely that the ozone standard will have a direct impact on the service sectors, however, we do expect that services, in particular *PSOTH*, may be sensitive to the production and investment climate of the area in which they originate. Declines in county-level *PSOTH*, or even *PSFIN*, may indicate a structural shift away from a county's manufacturing activities.

The dataset also includes county data for the manufacturing and service sectors at the 2-digit SIC level. The U.S. Bureau of the Census collects this data for all major sectors every five years in the Economic Census (U.S. Bureau for the Census, Economic Census 1992, 1997).[3] As with the annual estimates described above, these data are also subject to disclosure restrictions and we report the extent of such non-disclosures (flags) in the tables that follow. For both manufacturing and services sectors we collected data on Total Revenue (*TR)* and Total Payroll (*TP*) and used these data to calculate county-level productivity measures. The Census Bureau changed the format in which it collected and organized data for the services sector between 1992 and 1997. For this reason, productivity measures for the services sector are aggregated across all sectors for 1992 and separated into the Real Estate, Professional and Management Services, and Health Care in 1997.

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[2] Estimates for some counties in Alabama were not available.
[3] The Bureau of Economic Analysis uses the Economic Census to estimate the annual data used in the REIS database. Total number of establishments is calculated form the Economic Census and estimated for the intervening years for the County Business Patterns.

We construct a measure of productivity for each county for 1992 and 1997:

$$\frac{\frac{TR_{i,j,t}}{TP_{i.j.t}}}{\frac{TR_t}{TP_t}} \qquad (1)$$

where $TR_{i,j,t}$/ $TP_{i,j,t}$ denotes *Total Revenue/Total Payroll* at county *i* in sector *j* at time *t*. Following McGuckin and Nguyen (1995) we recognize the importance of normalizing productivity measures by the national productivity ratio and divide productivity by the ratio of Revenue to Payroll at the national level at time *t*. Commonly, manufacturing productivity is estimated by dividing estimates for value-added by total employment to get an estimate of output per worker. However, in the services sector, there are no estimates for value-added, making it impossible to estimate productivity under this definition. We believe that our ratio effectively captures the productivity of service firms and although it is not an ideal measure for manufacturing productivity, we apply this to manufacturing for two reasons. First, the data is publicly available and second, we chose to maintain consistency across sectors. This measure allows for the possibility that some firms may choose to employ a large number of less productive, low-wage workers while other firms may choose to employ fewer, but more productive high-wage workers.

To control for the regional trends in these economic measures we divide the U.S. into four main regions: Midwest, South, Northeast, and West. This partition is used to create dummy variables in the econometric section (Section 6) of the paper. Following Glaeser (1995) we set the West as the base variable against which the other three regions can be compared.

Attainment classification serves a dual role as a regulatory and environmental variable for each county and is published annually in the Code of Federal Regulations (CFR). In the descriptive statistics we classify a county that does not achieve the ozone standard at any level as a non-attainment county, however, in our ordered probit model we account for the degree to which a non-attainment county is out of compliance with the ozone air quality standard. Although data was available to assign each classification of attainment status a number from 0 to 6 with 0 indicating *attainment* and 6 denoting *extreme,* there were not sufficient numbers of counties in each county to identify the model. To compensate, we combined the six categories into four with 0 representing *attainment*, 1 indicating *marginal*, 2 combining *moderate* and *serious* classifications, and 3 combining *severe 15*, *severe 17,* and *extreme* into the last category. This allows us to capture the gradients in levels of regulatory intensity inherent in the attainment variable. As noted earlier, the regulatory impacts of a *marginal* non-attainment designation are less stringent than those designated as *extreme* or *severe*. A total of 17 counties were classified under Section185(a) of the Clean Air Act (40 CFR part 81) for at least one time period and were dropped from the dataset for that year.[4]

5. Statistical Results

This section first presents the descriptive statistics at the broadest level, the fraction of the U.S. population and manufacturing establishments categorized by the above taxonomies. We then make comparisons of the average per capita personal income, wage per worker, and productivity measures across the subcategories of counties and find statistically significant differences. Last, we investigate the relative economic performance and industry composition of the various county subpopulations to determine whether the areas out of compliance with the ozone air quality standard face adverse economic consequences or shift away from polluting

[4] A Section 185(a) classification means either that insufficient data was available for a classification to be made or that a designation could not be assigned for other reasons.

industries to more service-oriented economies. If there is a shift towards the service sector, we want to determine if it occurred across all counties or only in those that did not meet the ozone standard.

5.1 County level income, wages, manufacturing employment, and productivity

Table 2 shows the percentage of the U.S. population in counties classified by metropolitan status and attainment designations. We see that 76 percent of the U.S. population lives in areas that are designated long-term metropolitan, while 2 percent of the population lives in new metropolitan areas. Each metropolitan category experienced slight growth in the 1990s. Although 43 percent of the population lives in long-term non-attainment counties, approximately 12 percent of the U.S. population lives in areas that achieved improved air quality during the 1990s and were removed from non-attainment status. The location of manufacturing establishments tends to mirror the population proportions in metropolitan and non-attainment areas. However, there is a slightly higher fraction of manufacturing establishments located in long-term non-attainment areas relative to the proportion of the U.S. population in these areas. In addition, we find that approximately 15 percent of establishments, or one-quarter of all establishments in non-attainment counties, were located in areas that achieved the air quality standard by the end of the decade.

We disaggregate the non-attainment areas according to their designations to show the proportion of all manufacturing establishments located in non-attainment areas. Figure 1 shows that the proportion of manufacturing establishments in non-attainment areas remained constant for all categories except for the groups of *marginal* and *moderate* non-attainment counties, which show decreases from 1994-1996. This is offset by an increase in the proportion of manufacturing plants located in attainment areas, which reaches a plateau in 1996. This shift in the fraction of manufacturing establishments located across attainment and non-attainment counties can be explained in part by the change in status of the short-term non-attainment counties to attainment status rather than a flight of manufacturing establishments to areas designated as attainment.

Table 3 provides descriptive statistics for *REL PCPI* for selected years and subpopulations of the taxonomies. Using a *t* test and testing at the 5% significance level we find there are statistically significant differences in mean values of *REL PCPI* across all categories. Examination of the attainment taxonomy shows that, for the years 1990, 1994, and 1998, the mean value of *REL PCPI* is significantly larger in long-term non-attainment areas than in areas that have been in long-term attainment (Category A). This ratio remains higher for long-term non-attainment areas when compared to short-term non-attainment areas (Category B).

[Insert Table 3 Here]

The results from Categories C and D are consistent with the well-known finding that PCPI is higher in metropolitan areas than non-metropolitan areas. This phenomenon is generally explained by increasing returns to specialization and human capital as population density increases (Sveikauskas, 1975, Becker *et al.*, 1999). We initially believed the results from Category E, that *REL PCPI* is higher in metropolitan areas designated as non-attainment relative than those designated as attainment, to be a result of differences in population density across metropolitan counties. It would seem plausible that metropolitan areas designated non-attainment might have higher population density and hence, higher *REL PCPI*, yet when we compare non-attainment counties with their attainment counterparts at equivalent population density levels, this relationship holds.[5] However, when we examined only the counties where manufacturing density is greater than 5.7 establishments per square mile (one standard deviation above the mean for all attainment areas), we found no difference in *REL PCPI* between attainment and non-attainment counties. Although PCPI cannot be considered entirely location-specific income because it also captures wage effects, transfer payments, and investment income, this does provide initial evidence that long-term non-attainment counties do not have lower personal income per capita measures, and taken as a whole, actually have higher incomes.

We further test this finding by comparing average county *WPW* measures, an indicator that is location-specific, for the same county subpopulations presented in Table 4. The results for the subpopulations examined in Categories A through E, though not discussed in detail here, were identical to those found for *REL PCPI*. When we controlled for population density, we found that long-term non-attainment areas had higher *WPW* relative to attainment areas, a result similar to that found for *REL PCPI*. For counties with manufacturing density greater than 5.7 establishments per square mile (one standard deviation from the mean for all attainment areas), *WPW* remained higher in the long-term non-attainment areas. If firms have relocated to attainment areas as some researchers have found (Becker and Henderson, 2000; Gray, 1997; Henderson, 1996; Yandle, 1984) it is an interesting result that wages remain higher in non-attainment areas despite firm migration. There is no overlap between the datasets from these analyses and ours (previous studies end where ours begin), so it is difficult to conclude that the regulations have had little effect on wages. Yet it is possible to infer that areas subject to the ozone air quality standard continue to command high wages.

[5] Results available upon request.

[Insert Table 4 Here]

To gain a better understanding of the proportion of employment derived from the manufacturing sector across the attainment and metropolitan taxonomies, we developed a ratio of manufacturing employment (*MEMP*) to non-farm employment (*NFEMP*) for select years in the 1990-1998 time period (Table 5). These ratios show that short-term non-attainment areas have a consistently higher proportion of manufacturing employment to non-farm employment relative to long-term non-attainment areas. The 125 counties that comprise the short-term non-attainment category came into compliance with the ozone air quality standard despite having higher average representation of manufacturing than those areas that remain in non-attainment (Category A). Table 5 also shows that new metropolitan counties, (those typically annexed by adjacent metropolitan areas) have a higher proportion of manufacturing employment than those counties that have been metropolitan for many years (Category B). That this ratio declines over time proportionately across all the categories provides further evidence that long-term non-attainment counties do not appear to be disproportionately disadvantaged by the ozone air quality standard.

[Insert Table 5 Here]

The performance measures discussed above tell only a partial story. Most researchers agree that productivity is the better indicator of economic performance, but also the most difficult to measure. We define and analyze both service sector productivity and manufacturing sector productivity for 1992 (Table 6) and 1997 (Table 7) where we again see significant, if slightly paradoxical, differences in means across the categories. Results presented in Table 7 for productivity of the service sectors reflect the changes in reporting made by the U.S. Census Bureau and are therefore disaggregated across major categories of services. For both service productivity and manufacturing productivity in both tables, we see a higher mean value for long-term attainment areas relative to long-term non-attainment areas (Category A). In the case of metropolitan areas, long-term non-metropolitan areas have higher mean values for both service and manufacturing sector productivity (Category B), though the values for manufacturing productivity across metropolitan and non-metropolitan areas are equal in 1997 (see Table 7 Category B).

Overall, these results seemingly contradict established agglomeration and knowledge spillover theories. Ciccone (1996) estimates that doubling employment density in a county increases average labor productivity by 6 percent and Sveikauskas (1975) finds a 5.98 percent increase in labor productivity as city size doubles. One explanation is that our analysis may be seriously limited due to the presence of data 'flags.' Flags indicate that the data was not published by the U.S. Census Bureau to prevent inadvertent disclosure of proprietary firm information. The number of flags for each subpopulation is reported to allow the reader to develop her own interpretation of the results.

[Insert Table 6 Here]

[Insert Table 7 Here]

We again attempt to control for the effect of metropolitan status by calculating the mean values of both service sector productivity and manufacturing productivity for those long-term attainment and non-attainment areas that are also designated as long-term metropolitan. For both

1992 service and manufacturing productivity measures presented in Table 6 Category C, long-term attainment areas that are also classified as metropolitan show higher mean values, but also higher standard deviations. The results for 1997 in Table 7 Category C show a significant difference in mean values of productivity in the manufacturing sector as well as in two of the three major service sectors.

It is clear that there are significant differences in the economic performance results measured by *REL PCPI*, *WPW*, and productivity for these counties, but the underlying economic structure that drives the differences in these measures is not immediately evident. While it is true that most non-attainment counties are part of metropolitan areas, we cannot fully explain the differences in income, wages, and productivity by metropolitan status alone. It could be that counties with relatively higher proportions of people and manufacturing establishments benefit from agglomeration economies though at the same time they are more likely to be designated non-attainment due in part to the strong historical presence of manufacturing establishments and people in these areas. The higher *REL PCPI* and *WPW* for long-term non-attainment areas support this conclusion, but the lower productivity measures do not. What our results in the next section do show is though non-attainment areas must comply with more requirements to achieve the ozone air quality standard, there is a larger, but declining, presence of the manufacturing sector in metropolitan long-term non-attainment areas over the study period. In addition, population density continues to increase in these areas even though the air quality is presumed to be worse (see Table 8).

5.2 Sectoral Composition and Density

The next tables report descriptive statistics for selected subpopulations on manufacturing and population densities and the share of wages in each economic sector, relative to the total county earnings. Although these tables do not show the dynamics nor the mechanism by which sectoral shifts occur, they do provide useful snapshots of the economic composition of counties over three time periods: 1990, 1994, and 1998. Table 8 shows manufacturing and population densities, manufacturing share, as well as the relative shares of distribution and producer, advanced consumer, and financial services for the subset of long-term metropolitan counties based on their long-term attainment status. As this table shows, metropolitan non-attainment counties have significantly higher manufacturing density than counties in attainment of the ozone standard. The table also shows a dramatic decrease in the mean manufacturing density of non-attainment areas while remaining virtually unchanged in metropolitan attainment counties over the 1990 to 1998 time period. The relative impact on the manufacturing composition of these counties, however, is not as high with an 11.6 percent decrease in non-attainment counties and 10.4 percent decrease in attainment counties. This suggests that while the number of manufacturing establishments declined precipitously in counties designated as non-attainment, the decline in manufacturing shares relative to their attainment counterparts was nearly equivalent. In contrast to the declining share of manufacturing over the study period, the shares of all service sectors (financial, other producer, and advanced consumer) except distribution have increased, indicating a general positive trend in services in the U.S. economy overall.

Another measure of interest is mean population density, which increased by 7 percent in metropolitan attainment counties, but increased only by 2 percent in metropolitan non-attainment counties. This is significant in light of the result from Table 2 that shows a slight decline in the *proportion* of the U.S. population living in non-attainment areas. While this can be interpreted as a decline in population *relative* to the U.S. population, the number of people per square mile in non-attainment areas still increased.

[Insert Table 8 Here]

The dataset is next partitioned to explore the sectoral taxonomy for counties that are as similar in attainment, metropolitan, and density characteristics as possible. For the years 1990, 1994, and 1998 we restrict the dataset to include only long-term metropolitan counties with population density greater than 0.87 persons per square mile (one standard deviation above the mean of long-term metropolitan counties in long-term attainment) and less than 1.42 persons per square mile (two standard deviations above the same mean). Pooled and Satterthwaite t-tests (Casella and Berger, 1996) indicate that in 1990 and 1994, none of the sectors have statistically significant differences in mean values between attainment and non-attainment counties. In 1998, *MFGDENS*, *ACS*, and *DIST* are statistically different. Most notable in this subset is that *MFGDEN*S actually increased by 15 percent from 1990 to 1998 in non-attainment counties, differing from the result presented in Table 8 for all metropolitan non-attainment counties. Table 9 shows an increase in mean manufacturing density from 1.7 establishments in 1994 to 2.3 establishments in 1998. Over this same period, manufacturing density declined by 9 percent in long-term attainment areas. This finding supports the conclusion that, for this subset of metropolitan areas with population density between 0.87 and 1.42 persons per square mile, the ozone air quality standard has not resulted in a decline in manufacturing density in non-attainment areas. Also notable is the rather large decline of the share of *DIST* in non-attainment areas relative to attainment areas.

[Insert Table 9 Here]

6. Econometric Model and Results

Clearly both manufacturing density and population density vary significantly across attainment and non-attainment counties. The composition of the county economies also varies. But the question remains, are there characteristics that may make it more likely for a county to be in or out of compliance with the ozone air quality standard? We estimate an ordered probit model (Greene, 1993) in order to test certain characteristics that may increase the propensity for a county to fail to attain the ozone standard. The ordered probit takes advantage of the ordinal nature of the attainment variable and is a means to control for regulatory intensity. The independent variables are the sectoral shares explored in the previous section in addition to controls for location and density. The following probit model was used with a sample of all counties (n = 3010) for the years 1990, 1994, and 1998:

$$\Pr ob(Y=0)=\int_{-\infty}^{\beta' X}\phi(t)dt, \qquad (2)$$

$$=\Phi(\beta' x_i), \qquad (3)$$

where x is a vector representing industry shares, *PRM, MFG, DIST, ACS, PSFIN*, and *PSOTH*, and the natural logarithm of the density measures, *POPDENS* and *MFGDENS*. We also control for regional effects in the model by adding the regional dummy variables where the West is the omitted variable.

In the ordered probit, *y* is the latent, or unobserved variable such that:

$$y^* = \beta' x + \varepsilon , \qquad (4)$$

but we can observe the following for various levels of y:

y=0 if $y^* \leq 0$,

y=1 if $0 < y^* \leq \mu_1$,

y=2 if $\mu_1 < y^* \leq \mu_2$,

.

.

.

y=J if $\mu_{j-1} \leq y^*$.

Table 10 shows the results of the ordered probit model, where the log-likelihood ratio-test was used to test the fit of the model. The coefficients and related standard errors are also reported. In 1990, the only significant variables when all counties are considered are population density (*LN POPDENS*), both financial producer services and other producer services (*PSFIN* and *PSOTH*) and the geographic dummy variables representing the Northeast (*NE*) and Midwest (*MW*) regions. By 1998, the significance of both producer service variables drop out leaving only population density and the same geographic variables as significant determinants of the probability that a county attains the ozone standard. This highlights the fact that neither the manufacturing density, nor the wage share from the manufacturing sector of the economy have a significant effect on the probability that county is in attainment.

Since the coefficients estimated in an ordered probit cannot be interpreted as the impact of a unit change in that variable, we report the marginal effects for the significant continuous variables in the estimation: the natural log of population density (*LN POPDENS*), financial producer services (*PSFIN*), and other producer services (*PSOTH*) in Table 11 (see Greene, 1993 for a discussion of calculating marginal effects). The marginal effects can be interpreted as the change in the probability of attaining the ozone air quality standard as a result of a unit change in a particular variable. As the ordered probit function is not linear, the marginal effects differ for different levels of attainment status. The reported marginal effects for population density are provided for a 10% change in the natural logarithm of population density (*LN POPDENS*) with all of the non-discrete variables held at their means (Subtracting the marginal effects between levels yields the marginal effect of a change in those levels, *i.e.*, to find the marginal effect of a change from $Pr(Y = 2)$ to $Pr(Y = 3)$, simply take the difference of the marginal effects.). Of particular interest is the sign change in the *LN POPDENS* variable for 1990. For those counties in the most extreme category, $Pr(Y = 3)$, a 10% increase in population density translates to a 7.6% decrease in the probability that the county will meet the ozone standard. In 1998, a 10% increase in population density translates to a 5.1% decrease in the probability of attaining the standard. The smaller marginal effects for the other levels of the attainment variable seem to indicate that the counties in the *severe* to *extreme* non-attainment categories are most sensitive to changes in population density.

The significant producer services variables, financial and other (*PSFIN* and *PSOTH*), are perplexing. Both are significant only in 1990 but seem to work in opposite directions. A 10% increase in financial services increases the probability a county will attain the ozone standard, while a 10% increase in other producer services decreases the chances of attaining the standard. The signs on the marginal effects remain the same through 1998 although the variables are not significant. The justification for the increasing prominence of *PSOTH* in metropolitan long-term non-attainment counties (see Table 8) is not immediately apparent and warrants further investigation. The share of *PSOTH* in metropolitan non-attainment counties averages 10% and grew to 11% from 1990 to 1998 and the next estimation shows an even stronger relationship.

We next restrict the sample to all metropolitan counties (*n*=712), whether they became metropolitan recently or not. To simplify the analysis, we estimate Equation (2) using a simple probit model where Pr($Y = 0$) is the probability that the county attains the standard and Pr($Y = 1$) is the probability that the county is in long-term non-attainment status. In this estimation, the vector x represents the same industry shares and geographic dummy as the earlier model and the density measures, *POPDENS* and *MFGDENS*. Table 12 shows the results from estimating Equation (2) in a standard probit estimation where the marginal effect is defined as:

$$\frac{\partial E[y \mid x]}{\partial x} = \phi(\beta' x)\beta$$

For each independent variable, the marginal effect, or slope, is listed beneath the standard error for each coefficient. In the restricted sample of only metropolitan counties, the wide variation in population density across counties is reduced, thereby constraining the explanatory power of *POPDENS* we saw in the previous estimation. Population density remains significant but its impact on the probability of attaining the ozone standard (-4.3% in 1990 and –5.8% in 1998) is dwarfed by the impact of the share of manufacturing in a county (*MFGSH*). The dramatic change in the probabilities over the decade might be attributable to the fact that as manufacturing share declines in long-term non-attainment counties overall (see Table 8), manufacturing has consolidated into a smaller number of counties, making attainment status even more difficult to achieve for those counties with high proportions of manufacturing.

This same logic might also explain the significance of the variable representing the distribution sector (*DIST*) in 1998, where increases in *DIST* indicate a 29.1% decrease in the probability of attaining the standard. The significant results for *PSOTH*, (represented by high-end financial and other services), can be explained by the explosion of this service sector into the highest performing areas. Unlike manufacturing, we cannot draw a causal link but infer that this is an indirect effect. Producer services tend to agglomerate in the areas that have the highest density of economic activity.

7. Conclusion and Discussion of Future Work

Overall, we find that areas classified as long-term non-attainment do not perform worse than their attainment counterparts. Although we cannot clearly say how the ozone air quality standard affected these counties, if at all, we can make general inferences about what the ozone air quality standard *did not do*. While we do see a decline in the number of manufacturing establishments per mile in metropolitan non-attainment counties, there is no evidence that the standard altered the *proportional* representation of manufacturing in non-attainment counties. When we follow the partitioned long-term metropolitan counties across time, we see that their manufacturing share declined regardless of the attainment status (Table 8). We also see an increase in both producer and consumer shares for both attainment and non-attainment areas.

In the highly restricted dataset comprised of counties with average population densities for metropolitan counties (Table 9), we see that manufacturing density of non-attainment areas actually increased and its manufacturing share decreased by a lesser amount than that of attainment counties. Figure 1 further shows the proportion of manufacturing establishments remained constant with the exception of the large redesignation of counties to attainment in 1994.

Our results also show that counties designated non-attainment do not appear to have lower income and wages, nor are they experiencing population flight. It is reasonable to expect that wages would also fall in the county categories where manufacturing declined significantly, however, this is not the case. Our results show that *WPW* actually increased over the study period, as did *REL PCPI*. Areas designated as long-term non-attainment also grew in population, but at a slower rate than their attainment counterparts. This could be an indirect indication of a disincentive to move to areas that are out of compliance with the ozone standard or may simply be explained by a 'crowding out' phenomenon; long-term non-attainment areas are, on average, more dense to begin with and therefore less attractive to newcomers.

The probit analysis begins to identify determinants of attainment status. Overall, an increase in population density will decrease the probability that the county will attain the ozone standard. This provides marginal support for our original hypothesis that non-attainment areas may simply be designated as such due to historical agglomeration of industry and population in the area. For metropolitan areas, population density is again important but the primacy of manufacturing activity continues to be the primary explanatory variable in the failure to attain the ozone standard. It will be important to track the dynamics of the overall decline in manufacturing as a proportion of county wages. Are some counties becoming so specialized in the manufacturing sector that it is infeasible to expect them to ever attain the ozone air quality standard?

This analysis raises further questions regarding the characteristics of counties that still fail to achieve the air quality standards over 20 years following the passage of the Clean Air Act. Furthermore, while we find no evidence that attainment regulations negatively impact a county economy, a natural extension of this work reverses the reasoning and uses a full econometric model of a county economy to test if attainment status is a negative determinant of county economic growth. Using panel data will allow us to control for county fixed effects. While this analysis provides a broad overview of characteristics of county economies, more research is needed to determine if there may be unanticipated effects, either positive or negative, of ozone attainment regulations on industries other than manufacturing.

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Table 1. Ozone Non-attainment Classifications

Classification	Description
Extreme	area with a design value of 0.280 ppm and above
Severe 17	area with a design value of 0.190 up to 0.280 ppm and has 17 years to attain the standard (from the year 1990, when the Clean Air Act Amendments were enacted)
Severe 15	area with a design value of 0.180 up to 0.190 ppm and has 15 year to attain the standard (from the year 1990)
Serious	area with a design value of 0.160 up to 0.180 ppm
Moderate	area with a design value of 0.138 up to 0.160 ppm
Marginal	area with a design value of 0.121 up to 0.138 ppm
Section 185(a)	area designated non-attainment as of the enactment date of the CAA Amendments of 1990, but has not violated the ozone NAAQS during the 36 month period immediately prior; or those areas without sufficient data to determine whether or not it is meeting the ozone standard

Table 2. Percentage of US Population and Manufacturing Establishments Located in Metropolitan and Attainment Classified Counties

Percentage of US Population in:	**1990**	**1994**	**1998**
LT METRO	76.28%	76.34%	76.57%
NEW METRO	2.08%	2.13%	2.21%
LT NON-ATT	43.65%	43.29%	43.31%
ST NON-ATT	12.40%	12.39%	12.35%

Percentage of US Manufacturing Establishments in:	**1990**	**1994**	**1998**
LT METRO	77.05%	75.89%	78.10%
NEW METRO	1.67%	1.78%	1.88%
LT NON-ATT	46.92%	44.73%	46.05%
ST NON-ATT	14.26%	14.43%	14.66%

Table 3. Descriptive Statistics for Relative PCPI Across Attainment and Metropolitan Taxonomies

	1990		1994		1998	
(A)	**Long-Term Attainment/Non-Attainment**					
	Att	Non-Att	Att	Non-Att	Att	Non-Att
N	2675	265	2674	265	2674	265
Mean	1.00	1.39	0.83	1.13	0.70	0.97
Std. Deviation	0.20	0.33	0.15	0.27	0.14	0.26
Coef. of Variation	0.20	0.24	0.19	0.24	0.20	0.26
(B)	**Short-Term and Long-Term Non-Attainment**					
	ST	LT	ST	LT	ST	LT
N	125	265	125	265	125	265
Mean	1.22	1.39	1.02	1.13	0.86	0.97
Std. Deviation	0.23	0.33	0.19	0.27	0.17	0.26
Coef. of Variation	0.19	0.24	0.18	0.24	0.20	0.26
(C)	**Long-Term Non-Metropolitan/Metropolitan**					
	Non-Met	Met	Non-Met	Met	Non-Met	Met
N	2255	714	2255	714	2255	714
Mean	0.98	1.25	0.81	1.04	0.68	0.89
Std. Deviation	0.19	0.28	0.15	0.22	0.13	0.21
Coef. of Variation	0.20	0.22	0.18	0.22	0.20	0.24
(D)	**New Metropolitan/Long-Term Metropolitan**					
N	New Met	LT Met	New Met	LT Met	New Met	LT Met
Mean	98	714	98	714	98	714
Std. Deviation	1.05	1.25	0.88	1.04	0.75	0.89
Coef. of Variation	0.16	0.28	0.12	0.22	0.11	0.21
	0.15	0.22	0.14	0.22	0.15	0.24
(E)	**Long-Term Metropolitan and Long-Term Attainment/Non-Attainment**					
	Met Att	Met Non-Att	Met Att	Met Non-Att	Met Att	Met Non-Att
N	391	224	391	224	391	224
Mean	1.14	1.42	0.95	1.16	0.81	1.00
Std. Deviation	0.19	0.33	0.16	0.27	0.15	0.26
Coef. of Variation	0.17	0.23	0.17	0.23	0.18	0.26

Table 4. Descriptive Statistics for Non-Farm Wage Per Worker Across Attainment and Metropolitan Taxonomies

	1990		1994		1998	
(A)	**Long-Term Attainment/Non-Attainment**					
	Att	Non-Att	Att	Non-Att	Att	Non-Att
N	2791	265	2791	265	2791	265
Mean	17,014	22,451	19,209	25,520	21,336	29,126
Std. Deviation	3280	4232	3762	5306	4164	6713
Coef. of Variation	0.19	0.19	0.20	0.21	0.20	0.23
(B)	**Short-Term and Long-Term Non-Attainment**					
	ST	LT	ST	LT	ST	LT
N	125	265	125	265	125	265
Mean	21,033	22,451	23,501	25,520	26,925	29,126
Std. Deviation	3303	4232	3847	5306	4555	6713
Coef. of Variation	0.16	0.19	0.16	0.21	0.17	0.23
(C)	**Long-Term Non-Metropolitan/Metropolitan**					
	Non-Met	Met	Non-Met	Met	Non-Met	Met
N	2340	714	2340	714	2340	714
Mean	16,477	20,778	18,550	23,693	20,557	26,764
Std. Deviation	3019	3814	3354	4684	3644	5638
Coef. of Variation	0.18	0.18	0.18	0.20	0.18	0.21
(D)	**New Metropolitan/Long-Term Metropolitan**					
	New Met	LT Met	New Met	LT Met	New Met	LT Met
N	98	714	98	714	98	714
Mean	17,856	20,778	20,235	23,693	22,761	26,764
Std. Deviation	3663	3814	3960	4684	4260	5638
Coef. of Variation	0.21	0.18	0.20	0.20	0.19	0.21
(E)	**Long-Term Metropolitan and Long-Term Attainment/Non-Attainment**					
	Met Att	Met Non-Att	Met Att	Met Non-Att	Met Att	Met Non-Att
N	490	224	490	224	490	224
Mean	19,781	22,959	22,545	26,206	25,276	30,004
Std. Deviation	3128	4253	3862	5311	4294	6759
Coef. of Variation	0.16	0.19	0.17	0.20	0.17	0.23

Table 5. Descriptive Statistics for Non-Farm Employment and Manufacturing Employment Across Attainment and Metropolitan Taxonomies

		1990		1994		1998	
(A)		**Short-Term Non-Attainment/Long-Term Non-Attainment**					
		ST Non-Att	LT Non-Att	ST Non-Att	LT Non-Att	ST Non-Att	LT Non-Att
NFEMP	N	125	265	125	265	125	265
	Mean	151,270	238,672	159,674	240,326	176,884	266,885
	Std. Deviation	228,486	478,164	235,710	458,188	261,795	493,447
	Coef. of Var.	1.51	2.00	1.48	1.91	1.48	1.85
MFGEMP	Mean	22,881	31,683	22,502	28,590	23,163	30,313
	Std. Deviation	34,001	70,997	31,661	59,119	32,414	60,255
	Coef. of Var.	1.49	2.24	1.41	2.07	1.40	1.99
MFGEMP/NFEMP		**0.15**	**0.13**	**0.14**	**0.12**	**0.13**	**0.11**
(B)		**New Metropolitan/Long-Term Metropolitan**					
		New Met	LT Met	New Met	LT Met	New Met	LT Met
NFEMP	N	98	725	98	725	98	725
	Mean	21,890	153,094	24,032	158,735	27,024	177,569
	Std. Deviation	20.490	319,870	22,429	310,451	25,692	339,138
	Coef. of Var.	0.94	2.09	0.93	1.96	0.95	1.91
MFGEMP	Mean	3,889	20,851	4,055	19,648	4,150	20,723
	Std. Deviation	3,970	47,289	4,153	40,135	4,307	41,325
	Coef. of Var.	1.02	2.27	1.02	2.04	1.04	1.99
MFGEMP/NFEMP		**0.18**	**0.14**	**0.17**	**0.12**	**0.15**	**0.12**

Table 6. Descriptive Statistics for 1992 Productivity Measures Across Attainment and Metropolitan Taxonomies

(A)	**Long Term Attainment/Non-Attainment**			
	Service		Manufacturing	
	Att	Non-Att	Att	Non-Att
N	2411	250	1931	228
N Flags	243	13	688	34
Mean	1.30	1.09	1.09	0.98
Std. Deviation	0.48	0.25	0.48	0.57
Coef. of Var.	0.37	0.23	0.44	0.58

(B)	**Long-Term Non-Metropolitan/Metropolitan**			
	Service		Manufacturing	
	Non-Met	Met	Non-Met	Met
N	1983	647	1593	614
N Flags	186	67	603	99
Mean	1.34	1.09	1.09	1.07
Std. Deviation	0.51	0.25	0.45	0.57
Coef. of Var.	0.38	0.23	0.41	0.53

(A)	**Long-Term Metropolitan and Long-Term Attainment/Non-Attainment**			
	Service		Manufacturing	
	Met Att	Met Non-Att	Met Att	Met Non-Att
N	344	213	322	197
N Flags	47	11	69	26
Mean	1.12	1.07	1.14	0.97
Std. Deviation	0.27	0.24	0.60	0.56
Coef. of Var.	0.24	0.22	0.53	0.58

Table 7. Descriptive Statistics for 1997 Productivity Measures Across Attainment and Metropolitan Taxonomies

Long Term Attainment/Non-Attainment

(A)

	Real Estate		Prof Services		Health Care		Manufacturing	
	Att	Non-Att	Att	Non-Att	Att	Non-Att	Att	Non-Att
N	2092	261	2352	247	2407	260	1566	251
N Flags	592	4	332	18	277	5	1118	14
Mean	1.11	1.09	1.25	1.06	1.03	0.98	1.06	0.98
Std. Dev.	0.47	0.56	0.45	0.28	0.23	0.11	0.47	0.46
Coeff. Of Variation	0.42	0.52	0.36	0.26	0.23	0.11	0.44	0.47

Long-Term Non-Metropolitan/Metropolitan

(B)

	Real Estate		Prof Services		Health Care		Manufacturing	
	Non-Met	Met	Non-Met	Met	Non-Met	Met	Non-Met	Met
N	1698	688	2003	621	2009	695	1211	657
N Flags	566	27	261	94	255	20	1053	58
Mean	1.12	1.07	1.27	1.06	1.04	0.98	1.05	1.05
Std. Dev.	0.50	0.43	0.47	0.26	0.25	0.12	0.44	0.51
Coeff. Of Variation	0.44	0.40	0.37	0.24	0.24	0.12	0.42	0.48

Long-Term Metropolitan and Long-Term Attainment/Non-Attainment

(C)

	Real Estate		Prof Services		Health Care		Manufacturing	
	Met Att	Met Non-Att	Met Att	Met Non-Att	Met Att	Met Non-Att	Met Att	Met Non-Att
N	369	222	324	210	2407	260	342	217
N Flags	23	2	68	14	277	5	50	7
Mean	1.07	1.08	1.08	1.05	1.03	0.98	1.10	0.98
Std. Dev.	0.34	0.59	0.26	0.29	0.23	0.11	0.55	0.45
Coeff. Of Variation	0.32	0.55	0.24	0.27	0.23	0.11	0.50	0.46

Table 8. Descriptive Statistics for County Characteristics and Industry Composition for LT Met Counties Across Attainment Taxonomies

		Long-Term Metropolitan and Long-Term Attainment/Non-Attainment							
		1990		1994		1998		Change 1990-1998	
		Attain	Non-Att	Attain	Non-Att	Attain	Non-Att	Attain	Non-Attain
	N	490	223	490	223	490	223		
MFGDENS	Mean	0.457	3.519	0.473	3.191	0.459	2.780	0.5%	-26.6%
	Std. Deviation	0.909	22.261	0.895	19.250	0.821	15.078		
	Coeff. Of Variation	1.988	6.325	1.890	6.032	1.786	5.423		
POPDENS	Mean	0.320	1.718	0.333	1.738	0.343	1.761	6.7%	2.4%
	Std. Deviation	0.550	5.771	0.552	5.804	0.545	5.863		
	Coeff. Of Variation	1.716	3.358	1.656	3.339	1.587	3.330		
MFGSH	Mean	0.220	0.200	0.214	0.190	0.199	0.179	-10.4%	-11.6%
	Std. Deviation	0.131	0.106	0.130	0.103	0.122	0.099		
	Coeff. Of Variation	0.593	0.529	0.608	0.541	0.610	0.550		
PSFIN	Mean	0.042	0.053	0.046	0.059	0.052	0.068	20.4%	22.9%
	Std. Deviation	0.024	0.031	0.028	0.035	0.032	0.042		
	Coeff. Of Variation	0.588	0.594	0.609	0.590	0.618	0.606		
PSOTH	Mean	0.073	0.098	0.076	0.102	0.085	0.118	14.5%	17.3%
	Std. Deviation	0.037	0.050	0.042	0.053	0.047	0.062		
	Coeff. Of Variation	0.511	0.512	0.550	0.520	0.553	0.528		
ACS	Mean	0.084	0.094	0.092	0.104	0.095	0.105	11.8%	10.7%
	Std. Deviation	0.039	0.037	0.041	0.042	0.042	0.042		
	Coeff. Of Variation	0.463	0.394	0.449	0.408	0.440	0.399		
DIST	Mean	0.088	0.094	0.085	0.092	0.086	0.094	-2.1%	0.3%
	Std. Deviation	0.048	0.049	0.044	0.051	0.046	0.048		
	Coeff. Of Variation	0.545	0.526	0.520	0.551	0.528	0.509		

Table 9. Descriptive Statistics for County Characteristics and Industry Composition for *LT MET* Counties for Population Density 0.87 < POPDENS < 1.42

		Long-Term Metropolitan and Long-Term Attainment/Non-Attainment							
		1990		1994		1998		Change 1990-1998	
		Att	Non-Att	Att	Non-Att	Att	Non-Att	Att	Non-Att
	N	17	26	22	29	25	36		
MFGDENS	Mean	1.788	1.895	1.788	1.740	1.634	2.234 **		
	Std. Deviation	0.694	0.911	0.632	0.795	0.629	1.226		
	Coeff. Of Variation	0.388	0.481	0.354	0.457	0.385	0.549		
POPDENS	Mean	1.082	1.147	1.086	1.115	1.090	1.170	0.7%	2.0%
	Std. Deviation	0.162	0.162	0.152	0.180	0.154	0.180		
	Coeff. Of Variation	0.150	0.141	0.140	0.161	0.141	0.154		
MFGSH	Mean	0.188	0.205	0.185	0.187	0.156	0.177	-20.8%	-16.0%
	Std. Deviation	0.102	0.086	0.096	0.085	0.088	0.066		
	Coeff. Of Variation	0.544	0.420	0.520	0.451	0.562	0.372		
PSFIN	Mean	0.075	0.067	0.079	0.073	0.091	0.089	17.3%	24.6%
	Std. Deviation	0.030	0.033	0.036	0.034	0.042	0.037		
	Coeff. Of Variation	0.401	0.491	0.469	0.471	0.461	0.413		
PSOTH	Mean	0.120	0.121	0.122	0.132	0.150	0.158	20.2%	25.1%
	Std. Deviation	0.032	0.046	0.033	0.052	0.048	0.065		
	Coeff. Of Variation	0.268	0.379	0.273	0.392	0.318	0.415		
ACS	Mean	0.109	0.096	0.113	0.110	0.108	0.128 **	-4.0%	-26.8%
	Std. Deviation	0.041	0.024	0.025	0.032	0.025	0.046		
	Coeff. Of Variation	0.379	0.248	0.223	0.287	0.234	0.358		
DIST	Mean	0.129	0.111	0.127	0.103	0.124	0.088 **	5.3%	0.8%
	Std. Deviation	0.046	0.081	0.043	0.084	0.042	0.032		
	Coeff. Of Variation	0.352	0.724	0.335	0.814	0.335	0.364		

** Indicates significantly different means at the 5% significance level. Densities are indicated in population/sq. mile. *POPDENS* > 0.87 is one standard deviation above the mean of *LT MET* counties in LT attainment. *POPDENS* > 1.42 indicates two standard deviations from the same mean.

Table 10. Attainment and County Economic and Demographic Composition
Estimation Procedure: Ordered Probit
Dependent Variable: Attainment Status (0=Attainment, 1,2,3 = Degrees of Non-attainment

	All Counties			
	1990		1998	
INTERCEPT	-1.31995	*	-0.92606	*
	(.27173)		(.32723)	
LN MFGDENS	0.07342		0.06701	
	(.09824)		(.12231)	
LN POPDENS	-0.83467	*	-0.75633	*
	(.10088)		(.12920)	
MFGSH	-0.67862		-0.05965	
	(.36693)		(.48966)	
DIST	-1.12363		-1.57917	
	(.82095)		(.99850)	
PSFIN	6.97808	*	1.78033	
	(2.25158)		(1.93532)	
PSOTH	-5.08838	*	-1.21072	
	(1.20758)		(1.29523)	
ACS	2.29266		2.67476	
	(1.13214)		(1.20057)	
MW	0.81591	*	1.05517	*
	(.14148)		(.16352)	
SOUTH	-0.04787		-0.02179	
	(.14091)		(.15178)	
NE	1.05701	*	1.10815	*
	(.14132)		(.15936)	
mu1	0.50666		0.2791	
mu2	1.03947		0.56213	

* Indicates significance at the 1% level. Standard errors in parentheses.

Table 11. Marginal Effects of Significant Variables for Ordered Probit Estimation

1990			1998		
Probability in attainment status	Coefficient	Marginal Effect	Probability in attainment status	Coefficient	Marginal Effect
LNPOPDENS					
Pr(Y = 0)	-0.83467	0.0075107	Pr(Y = 0)	-0.75633	0.01529418
Pr(Y = 1)		0.0191511	Pr(Y = 1)		0.01378813
Pr(Y = 2)		0.0499383	Pr(Y = 2)		0.02245403
Pr(Y = 3)		-0.0766	Pr(Y = 3)		-0.0515363
PSFIN					
Pr(Y = 0)	6.97808	-2.706735	Pr(Y = 0)	1.78033	-0.7099154
Pr(Y = 1)		0.0222588	Pr(Y = 1)		0.01471541
Pr(Y = 2)		0.6669302	Pr(Y = 2)		0.06529365
Pr(Y = 3)		2.0175462	Pr(Y = 3)		0.62990637
PSOTH					
Pr(Y = 0)	-5.08838	1.999873	Pr(Y = 0)	-1.21072	0.4825928
Pr(Y = 1)		-0.388383	Pr(Y = 1)		-0.0275609
Pr(Y = 2)		-0.637963	Pr(Y = 2)		-0.058584
Pr(Y = 3)		-0.973527	Pr(Y = 3)		-0.3964478

Note:

$Y = 0$	County is in attainment of the ozone standard
$Y = 1$	County is in marginal non-attainment status
$Y = 2$	County is in moderate or serious non-attainment status
$Y = 3$	County is in severe or extreme non-attainment status

Table 12. LT Attainment and County Economic and Demographic Composition
Estimation Procedure: Probit
Dependent Variable: Long-Term Attainment Status (0=Attainment, 1=Non-attainment)

		Long-Term Metropolitan Counties			
		1990		**1998**	
INTERCEPT		0.88914	*	1.13582	*
		(.28166)		(.29117)	
MFGDENS	Coefficient	-0.10687		-0.07894	
	Std. Error	(.09876)		(.10347)	
	Slope	-0.0357666		-0.02593	
POPDENS	Coefficient	-0.12955	*	-0.17817	*
	Std. Error	(.16359)		(.15460)	
	Slope	-0.043357		-0.05852	
MFGSH	Coefficient	-0.9977	*	-1.4079	*
	Std. Error	(.50057)		(.54895)	
	Slope	-0.3339044		-0.46241	
DIST	Coefficient	-1.85945		-3.36434	*
	Std. Error	(1.12493)		(1.16445)	
	Slope	-0.1630526		-0.29107	
PSFIN	Coefficient	-0.49041		-1.32878	
	Std. Error	(2.70420)		(2.14147)	
	Slope	-0.0214768		-0.07359	
PSOTH	Coefficient	-3.37064	*	-3.71706	*
	Std. Error	(1.34818)		(1.31719)	
	Slope	-1.1280662		-1.22083	
ACS	Coefficient	-0.57463		0.17274	
	Std. Error	(1.60013)		(1.46713)	
	Slope	-0.1923138		0.056734	
MW	Coefficient	0.99678	*	1.05011	*
	Std. Error	(.19208)		(.19560)	
	Slope	0.3335965		0.344897	
SOUTH	Coefficient	-0.39306	**	-0.4073	**
	Std. Error	(.18942)		(.19162)	
	Slope	-0.131547		-0.13377	

		1990		1998	
NE	Coefficient	1.08222	*	1.11976	*
	Std. Error	(.18564)		(.18801)	
	Slope	0.3621911		0.367772	

* Indicates significance at the 1% level

** Indicates significance at the 5% level

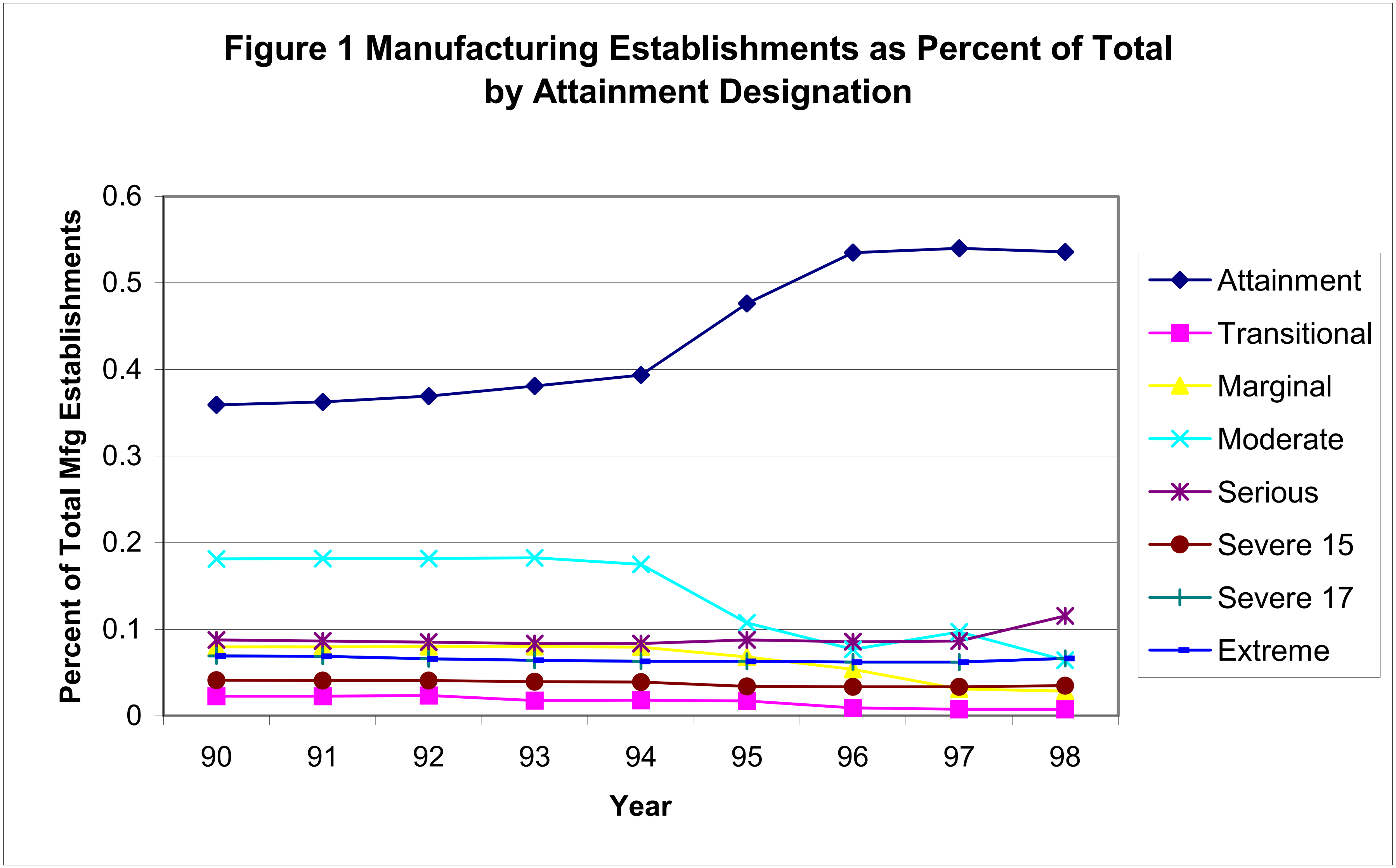
Figure 1 Manufacturing Establishments as Percent of Total
by Attainment Designation
Percent of Total Mfg Establishments
0.6
0.5
0.4
0.3
0.2
0.1
0
90
91
92
93
94
95
96
97
98
Year
Attainment
Transitional
Marginal
Moderate
Serious
Severe 15
Severe 17
Extreme

Appendix A. Industry Composition of Six Traded Goods & Services

Category	SIC Code
Primary (PRM)	
Agriculture, forestry, and fisheries	01-09
Mining	10-19
Manufacturing (MFG)	
Food & kindred products	20
Tobacco	21
Textiles	22
Apparel	23
Lumber & Wood Products	24
Furniture & fixtures	25
Paper & allied products	26
Printing & publishing	27
Chemicals & allied products	28
Petroleum & coal products	29
Rubber & miscellaneous plastic products	30
Leather & leather products	31
Stone, clay & glass products	32
Primary metals	33
Fabricated metals	34
Industrial machinery & equipment	35
Electronic & other electrical equipment	36
Transportation equipment	37
Instruments & related products	38
Miscellaneous manufacturing	39
Distribution (DIST)	
Railroad transportation	40
Trucking & warehousing	42
Water transportation	44
Transportation by air	45
Pipelines except natural gas	46
Wholesale trade	50-51
Financial Producer Services (PSFIN)	
Depository institutions	60
Nondepository institutions	61
Security & commodity brokers	62
Insurance carriers	63
Insurance agents & brokers	64
Real estate	65
Holding & other investment offices	67
Other Producer Services (PSOTH)	
Communication	48
Business services	73
Legal services	81

Category	SIC Code
Engineering & management services	87
Services not elsewhere classified	89
Advanced Consumer Services (ACS)	
Motion pictures	78
Amusement & recreation services	79
Health services	80
Educational services	82
Museums, botanical, zoological gardens	84

Source: Drennan (1999)