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Industrial Pollution and Civic Capacity in Metropolitan America

by

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ABSTRACT

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Environmental justice research analyzes inequalities by race and class in exposure to unhealthful toxins in the air, land, and water. These inequalities are typically considered at relatively small scales, such as neighborhoods, because these scales most effectively correspond to the area of exposure. This important focus on neighborhoods, though, is paralleled by a growing research agenda on disparities and patterns at larger scales, such as metropolitan areas, that are theorized to affect exposure to toxins at lower scales.

This dissertation investigates disparities in exposure to industrial pollution across metropolitan areas. The emergent research on the topic has not particularly identified mechanisms or processes that contribute to disparities across urban areas at the same time that wide variations have been described. To fill this research gap, I turn to a framework that centers on civic capacity to analyze how and why these disparities have emerged. The analysis is conducted using the Risk-Screening Environmental Indicators Geographic Microdata (RSEI-GM), which uses fine-grained air pollution data that takes into account the toxicity of chemicals from more than 20,000 facilities in the United States, and how these data correspond to risks to human health.

The findings suggest the utility of a civic capacity framework in three primary findings. First, I explicate how different measures of social capital organizations, which are based on the bridging or bonding nature of social ties, are correlated with levels of exposure to unhealthful toxins from industrial polluters. Second, I dive further into a discussion of social capital organizations by examining religious congregations, and finding that greater numbers of congregations are associated with accentuated or attenuated racial inequalities in exposure depending on the type of religious congregation under examination. Third, I find that the changing manufacturing base of a metropolitan area is associated with industrial pollution such that urban areas that have lost manufacturing jobs from 1970 to 2010 are particularly disadvantaged in exposure to unhealthful toxins. Taken together, these findings argue that civic capacity underwrites capacities for social justice, including environmental justice, in metropolitan areas in the United States.

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Nomenclature

ACS – United States Census American Community Survey

EPA – United States Environmental Protection Agency

GIS – Geographic Information Systems

RCMS – Religious Congregations & Membership Study

RSEI-GM – Risk-Screening Environmental Indicators Geographic Microdata

CHAPTER ONE: INTRODUCTION

This dissertation hinges on the simple observation that our cities are different from one another. Some differences are obvious. Portland, Oregon has more residents than Portland, Maine. Boston is more than two hundred years older than Seattle. Few would confuse New York City with Los Angeles.

Less obvious is the air above us. But disparities in exposure to industrial air pollution are among some of the largest differences seen across cities. Identifying and analyzing these disparities across cities in the United States comprises the essential task of this dissertation.

The findings in this research highlight these differences. Some cities – like the one in which this dissertation is defended – have a highly disproportionate share of the country's industrial pollution, while others are relatively unexposed to health risks from these facilities. These disparities differentially impact the size and extent of racial inequalities within metropolitan areas. But while environmental justice research on health inequalities from air pollution often analyzes differences across places, this research typically conceives of places as neighborhoods, leaving aside potentially crucial questions about other scales like metropolitan areas.

Why these disparities emerge guides the research questions in the dissertation chapters that follow. Several areas of interest prompt how and why metropolitan disparities in industrial pollution have emerged, but this research has had limited success analyzing specific mechanisms at work. I instead identify new areas by building a theoretical argument about civic capacity and testing that argument in empirical models.

The importance of this study is compelled by the health risks to which individuals are exposed from chemicals emitted by toxic facilities. The air pollution data compiled in the analysis are state-of-the-art, utilizing the latest GIS modeling and toxicology data to assess the toxicity of more than 400 chemicals from more than 20,000 facilities. It provides a clear picture of who is exposed to long-term health risks, like cancers, from man-made industrial pollutants—as well as who is not. The implications for human health in the metropolitan United States are evinced in the social pathways of exposure to industrial air pollution.

In this introduction, I detail previous approaches to the study of environmental inequality, and highlight how the present research extends this research forward to a new area. I then discuss how other scholars have conceptualized metropolitan disparities in industrial pollution. I argue that these scholars did not account for civic capacity in our cities, and that this area of investigation will aid in understanding inequalities in exposure to toxic air. The perspective is then tested in three empirical chapters, which are summarized here in this introduction.

1.1 Identifying Metropolitan Disparities

Research and advocacy in the environmental justice tradition analyzes and protests the disproportionate burdens of pollution experienced by marginalized populations (Mohai et al. 2009). Environmental justice contestations emerged out of decades of civil rights activism, growing technical knowledge among affected communities about pollution, and partly in contradistinction to environmental movements that did not often focus on issues relating to race (Cole and Foster 2001; Martinez-Alier et al. 2015; Schlosberg 2007; Spears 2014; Taylor 1997). Research followed. Pioneered by studies identifying disparities across places (Bryant and Mohai 1992; Bullard 1983; General Accounting Office 1983; United Church of Christ 1987), early studies primarily confirmed the disparities by race and class, although other early studies questioned these findings (Anderton et al. 1994; Bowen 2002; Oakes et al.1996).

These disparities at that time and in the three decades since has primarily focused on one scale: neighborhoods. Despite early debates (Mohai et al. 2009), research across dozens of studies finds compelling evidence that people of color and lower-income residents live closer to toxic facilities (Ard and Fairbrother 2016; Mohai and Saha 2007), and are exposed to high levels of health risks from air pollutants (Ard 2015; Downey and Hawkins 2008; Liévanos 2015). These studies have focused on how organizations (Grant et al. 2010; Prechel and Zheng 2012), migration patterns (Crowder and Downey 2010; Pais, Crowder, and Downey 2013), racial discrimination (Mohai and Saha 2015a; Pulido 2000), and differences in social capital (Ard and Fairbrother 2016; Pastor, Sadd, and Hipp 2001), among other topics, create and sustain these environmental inequalities across neighborhoods.

For research on air pollution in particular, recent advances in modeling of air pollutants more closely tracks how toxic pollutants are for human health. Previous research either relied on air pollution monitors in specific locations like single cities that could test relative toxicity levels (as is the case of much public health research on environmental disparities; e.g. Bruhl, Linder, and Sexton 2013; Hun et al. 2009), or on proximity to facilities in a city-specific or national analysis (as is the case in much of the social scientific literature on the subject; e.g. Downey 2006; Mohai and Saha 2007). This meant that conducting an analysis that (a) accounted for the relative toxicity of pollutants

(b) in a national analysis was not a particularly plausible endeavor until the last decade or so. An example of a database that addresses both of these gaps is the data on industrial pollution utilized in this study, the Risk-Screening Environmental Indicators Geographic Microdata (RSEI-GM). Developed by the United States Environmental Protection Agency, the RSEI-GM uses data from more than 20,000 large industrial facilities in the United States, and from more than 400 chemicals emitted from these facilities. A critical element of the data is that it takes into account the relative toxicity of each chemical from the facilities as well as the size of that emission. (For a detailed explanation of the data, please examine the methodology sections of chapters two, three, and four). This moves forward city-specific research using the best science from this research and extending to a much larger scale, namely that of the whole of the United States. It also advances social scientific research on the incidence of facilities by not considering each facility as equal in its pollution output; rather, it acknowledges the uneven health risks from the emissions across the facilities.

With this crucial step of acknowledging relatively toxicity of chemicals and the size of emissions across the United States, research is breaking new ground that better elucidates the patterns and implications of environmental inequalities. Three examples illustrate this point. First, Mary Collins and co-authors (2016) find that about ninety percent of industrial pollution in the United States is emitted from fewer than ten percent of facilities. This highly uneven pollution burden disproportionately disadvantages minority populations. Second, higher levels of pollution in a metropolitan area are also found to attenuate the extent of racial inequalities in that metropolitan – although not fully – because of deep unevenness in the overall toxicity of chemicals (Ash et al. 2013).

One implication is that the most toxic metropolitan areas are so toxic that most or all residents are affected by the highly risky emissions. Third, Kerry Ard (2015) shows in a study of industrial emissions from 1995 to 2007 that there are sizable variations in levels of toxic air across ten EPA regions during the time period. These variations are not just in absolute levels, but also affect the extent of racial inequalities as well as the factors that are associated with those inequalities. Taken together, these three examples showcase the utility of using a national framework to study exposure to unhealthful toxic air. They show that pollution can vary in ways previously not studied: by organization, by metropolitan area, and by region.

1.2 Analyzing Metropolitan Disparities

As suggested especially by Ash et al. (2013), disparities across metropolitan areas in exposure to industrially produced toxic air would structure neighborhood exposure, especially environmental inequalities across neighborhoods. An emergent core of research examines these questions, but with limited insight into the trends and patterns at play in environmentally inequality. For example, spatial inequality, such as residential segregation, is not consistently linked to air pollution outcomes (Ard 2016; Downey 2007; Downey et al. 2008; Lopez 2002; Morello-Frosch and Jesdale 2006). Little or no evidence has been found for metropolitan patterns of racial inequality (Downey 2007) nor for urban areas with more people of color associated with greater exposure to air pollution (Ard 2016; Downey et al. 2008).

Instead, I aver that utilizing a *civic capacity framework* can better elucidate patterns of metropolitan disparities in industrial pollution. A civic capacity framework could be considered within the aegis of David Pellow's "environmental inequality formation," which stresses four components of environmental injustice. Pellow writes:

> "How is environmental racism produced? To answer this question, I propose a framework that emphasizes the importance of the *history* of environmental racism and the processes by which it unfolds, the role of *multiple stakeholders* in these conflicts, the effects of *social stratification* by race and class and the ability of the least powerful segments of society to *shape the struggle for environmental justice*" (Pellow 2002:7; italics original).

Most quantitative social scientific research in the environmental justice tradition does not take into account measures that can touch on all four of these; for instance, social stratification is usually included in most studies with measures of neighborhood composition by race and class, but testing for stakeholders such as through local organizations or by examining historical trends is left aside.

A civic capacity perspective moves forward previous research by conceptualizing more than just social stratification, and instead by emphasizing how social capital organizations and metropolitan manufacturing history fill in important gaps about multiple stakeholders, history, and the struggle against environmental injustice. I aver that differential levels and types of connections within and through social capital organizations provides a foundational level of civic capacity in a metropolitan area. This civic capacity both provokes and inhibits possibilities for justice, including environmental justice, in an urban area. It may operate through a scalar disjuncture whereby metropolitan areas with more civic capacity can end up extending inequalities insofar as the civic capacity is directed toward ends that are more local and parochial

(Rudel 2013). Moreover, historical trends in pollution-intensive manufacturing industries both inform and become a product of lasting trends in civic capacity. In this way, civic elites position the economy of urban areas toward or away from polluting industries (Molotch, Freudenberg, and Paulsen 2000). Across history, the civic capacity of a given urban area is a powerful factor in enduring environmental inequalities.

1.3 Discussion of Chapters

Proceeding with this theoretical framework, this dissertation investigates inequalities in exposure to industrial pollution. The three chapters that follow make the case. A concluding chapter describes the findings, and explicates on common mechanisms across the chapters. Chapter Two analyzes how the amount and type of social capital organizations is related to the differential levels of toxic air across neighborhoods and cities. I begin by detailing a theoretical argument that analyzes the defensive environmentalism dynamic (Rudel 2013), and how a civic capacity framework can fill critical research gaps in the study of industrial pollution. Specifically, I describe two different types of social capital organizations (Kwon, Helfin, and Ruef 2013; Paxton 2007). The first are connected organizations, where the average member of such groups has a greater number of ties to other social capital organizations. By contrast, members of isolated organizations, the second type, have fewer ties to other social capital organizations. Previous research outlines that being a connected organization or isolated organization is patterned by organizational type. For example, civic associations and human rights organizations tend to be connected organizations, while religious organizations and sports clubs are more often found to be isolated organizations.

To conduct the analysis in Chapter Two, I compute the number of connected social capital organizations and the number of isolated social capital organizations per 10,000 residents in a metropolitan area. These measures are included in a multilevel statistical analysis that foregrounds how both metropolitan and neighborhood characteristics shape local pollution outcomes. The primary finding is that there are large differences across metropolitan areas in health risks from industrial air pollutants, and that these differences are associated with the presence of the two types of social capital organizations. Metropolitan areas with more connected organizations are comprised of neighborhoods exposed to fewer health risks, and metropolitan areas with more isolated organizations are exposed to greater health risks. The most disadvantaged urban areas, then, are places with few connected organizations, but many isolated organizations. A second set of findings detail how these organizations link to racial inequalities. I argue that metropolitan factors are a part of "recipes" of risky emissions (Grant et al. 2010). In addition to the metropolitan findings by type of organization, I find that neighborhoods with more black residents are exposed to more toxic air in urban areas with more connected organizations. Neighborhoods with more Hispanic residents in metropolitan areas with more connected associations, on the other hand, are associated with less exposure to toxic air. Urban areas with more isolated organizations are associated with greater exposure for these neighborhoods with more Hispanic residents. In summary, the findings in Chapter Two support the importance of the civic capacity perspective, particularly the multifaceted and multilevel links between social capital organizations and industrial pollution.

Chapter Three moves the social capital discussion to a more specific set of organizations – religious congregations – to further test key insights from Chapter Two as well as to extend them. In the discussion of connected and isolated organizations, religious organizations are understood as isolated organizations (Kwon, Helfin, and Ruef 2013; Paxton 2007). Research on religious congregations, however, demonstrates the relative levels of ties within the broad category of religious organizations can vary by religious type (Beyerlein and Hipp 2005; Blanchard et al. 2008; Shihadeh and Winters 2010). The three largest types of religious congregations in the United States differ on these points. On one hand, members of Evangelical congregations primarily have social ties that bond together group members (Hoge et al. 1998; Wilson and Janoski 1995; Wuthnow 1999). On the other hand, members of Catholic congregations and Mainline Protestant congregations often have bridging social ties that connect beyond organizational boundaries (Iannaccone 1994; Welch, Sikkink, and Loveland 2007; Wuthnow 1999). Within the world of religious congregations, Evangelical congregations could be considered isolated organizations while Catholic and Mainline Protestant congregations could be thought of as connected associations.

Following a similar methodological approach to the previous chapter, Chapter Three utilizes multilevel models to determine whether the density of each of these three types of religious organizations are associated with levels of industrial pollution exposure across metropolitan areas, and with patterns of neighborhood inequalities. Urban areas with more Evangelical organizations have higher levels of industrial air pollution, and wider inequalities by race. This pairs with the bonding social capital or isolated social capital thesis that places with more intra-organizational ties being associated with worse social outcomes. The evidence for Catholics and Mainline Protestant demonstrate mixed evidence in support of theses about bridging social capital and connected social capital organizations. The Catholic organizations and the Mainline Protestant measures are not associated with metropolitan disparities in industrial pollution, but are with the patterns of racial inequalities in that urban areas with more Catholic congregations or Mainline Protestant congregations have attenuated inequalities. Together, these findings foreground the importance of the civic capacity perspective on health risks by illustrating how different levels of different types of religious organizations are linked to inequalities in exposure to air pollution.

Chapter Four investigates how changes across time in the local composition of the manufacturing sector and overall population of residents is connected to industrial pollution exposure. Given the wide disparities across metropolitan areas in industrial air pollution, the historical trajectory of the economy – as affected by actions of civic, economic, and governmental elites – might condition contemporary health risks from large industrial facilities. For example, the composition of the economy in 1970 might be more highly associated with industrial pollution because it would structure the urban form and economic history of the place for contemporary times. Not only this, decisions made in previous eras would have occurred with less regard for environmental risk compared to recent years (Elliott and Frickel 2015; Spears 2014). The cumulative effect of the globalization and automation of the manufacturing workforce could mean that the pollution outcomes were fixed at points previous in historical time.

The findings in Chapter Four detail this directly in two primary sets of findings. First, and in confirmation of environmental inequality research on manufacturing and the neighborhood level (Elliott and Smiley 2016; Sicotte and Swanson 2007), the share of the workforce in manufacturing occupations in 2010 is associated with greater health risks. This same relationship is also found for the 1970 manufacturing composition: more manufacturing workers in that year is associated with greater industrial pollution exposure. Similar relationships are found for population size in both 1970 and 2010. Larger cities are exposed to greater toxic air. Second, I analyze change in manufacturing occupations and changes in population across time. Somewhat counter-intuitively, metropolitan areas with declines in manufacturing jobs in the period from 1970 to 2010 are associated with *greater* health risks from industrial pollution. Urban areas with population decline exhibit a similar pattern toward more industrial air pollution. These findings suggest that history matters: the composition of the economy in decades past deeply conditions contemporary pollution outcomes in the United States.

1.4 Conclusion

Across these chapters, the goal of the research can be distilled to a few programmatic ideas. New methodological developments on air pollution enable a closer examination of the health risks from large industrial facilities in the United States. Previous environmental justice research primarily focused on disparities across neighborhoods, and using these new methodological techniques provides a possible path to answer why neighborhood are shaped by the metropolitan areas in which they are nested. I identify several mechanisms associated with industrial pollution exposure, including how different types of social capital organizations and religious congregations are differentially linked to environmental inequalities. Additionally, places with manufacturing and population declines in recent decades are also connected to greater health risks. Environmental justice remains a critical concern because of the large disparities across geography, especially between metropolitan areas, and by race in this study.

CHAPTER TWO: SOCIAL CAPITAL, RACE, AND AIR POLLUTION IN METROPOLITAN AMERICA

As environmental justice (EJ) research powerfully documents, inequalities in exposure to environmental degradation are patterned by race (Ard 2015; Bullard 1990; Collins, Munoz, and JaJa 2016; Liévanos 2015; Mohai and Saha 2015a). Our metropolitan areas are particularly acute sites of such inequality, as urban areas are historically sites of agglomerated economic capital that produce tremendous pollution in deeply uneven ways (Engels [1844] 2013; Pellow 2002; Schweitzer and Stephenson 2007). This deeply uneven pattern is not just *within* urban areas, as research on racial environmental inequalities has shown (Ard 2015; Collins, Munoz, and JaJa 2016), but also *across* urban areas where the amount of pollution can vary widely (Ash et al. 2013; Downey 2007).

To better understand this heterogeneity, research on metropolitan variation in environmental inequality has emerged to articulate mechanisms that shape racialized neighborhood outcomes, but with limited success. Findings have focused on how racial residential segregation worsens environmental inequality, but mixed findings are found across studies (Ard 2016; Downey 2007; Downey et al. 2008; Lopez 2002; Morello-Frosch and Jesdale 2006). Other research highlights how income inequality fails to play a meaningful role (Downey et al. 2008), and some research finds that there is an association between overall levels of pollution and unequal exposure to environmental risk (Ash et al. 2013). This research occurs alongside and in response to a large body of single-city studies that analyzes racial disadvantage, sometimes with results that foreground different racial groups as experiencing the most disadvantage (Downey

2007). Research on the organizational characteristics of polluting firms and facilities shows how these factors condition environmental inequality (Collins, Munoz, and JaJa 2016; Currie et al. 2015; Grant et al. 2010), but leaves aside questions about which metropolitan areas host the most toxic facilities.

Approaches studying environmental justice at the metropolitan, neighborhood, and organizational level, in addition to case studies, offer important insights, but remain incomplete, especially in the attention paid to the social organization of urban areas. Environmental sociology generally and EJ research specifically have long theorized about the uneven spatial effect of organized neighborhoods as well as inequalities in social capital. From the importance of not-in-my-backyard (NIMBY) movements (Bullard 1990) to defensive environmentalism that inhibits efforts to scale up environmental concerns (Rudel 2013), EJ's theoretical framework on place-based social organization, in contrast to much of the research on social capital in cities and counties in the United States (e.g. Chetty et al. 2014; Shoff and Yang 2013), avers that aggregated, place-based social capital can extend inequalities, not ameliorate them. Yet, despite these theoretical offerings, we have no measurable sense of how the social organization of metropolitan regions is correlated with inter-urban exposure to pollution, and patterns of racial environmental inequality.

The present study aims to address this gap in several steps. First, I review important literature on environmental justice and metropolitan areas, and illuminate how gaps in existing research can be filled by testing for social capital. I then suggest that organization-based social capital not only is associated with the unequal distribution of harmful industrial pollution, but does so in countervailing ways. That is, I follow previous research on two diverging types of organizational social capital – connecting and isolating – and show how the former is associated with less metropolitan pollution while the latter is associated with greater exposure to toxic air (Paxton 2007; Kwon, Heflin, and Ruef 2013). Finally, I investigate how these forms of organizational social capital may also extend or ameliorate racial inequalities in exposure to toxic pollutants, and how this may occur in divergent ways for blacks and Hispanics. Taken together, this research seeks to answer important questions about how metropolitan areas segregate pollution, why differences in racial environmental inequalities have emerged across cities, and the differential mechanisms through which social capital operates.

2.1 Literature Review

2.1.1 Environmental Justice Across Urban Areas

Environmental justice research illuminates the pervasive racial inequality in exposure to toxic risks in the United States (Bullard 1990; Mohai, Pellow, and Roberts 2009). National studies especially confirm the disproportionate effects experienced by blacks, Latinos, and other minority groups (Ard 2015; Ash and Fetter 2004; Crowder and Downey 2010; Downey 2007; Liévanos 2015). Much of EJ research has studied single cities or metropolitan areas in an attempt to understand within-city patterns of racial environmental inequality, and the role that distinct forms of urbanization have played in the creation of it (e.g. Abel and White 2012; Krieg 1995; Pastor, Sadd, and Hipp 2001; Raddatz and Mennis 2013; York et al. 2014). While the reach of race in determining neighborhood outcomes across these studies is wide (Mohai et al. 2009; Taylor 2014), findings regarding the most disadvantaged population can vary. For instance, in cities such as Houston and Phoenix, Hispanics are most disadvantaged in terms of exposure to environmental degradation (Chakraborty et al. 2014; Grineski et al. 2007), but in cities such as Detroit and Philadelphia, blacks are the most disadvantaged (Downey 2006; Sicotte 2014). Downey (2007) illustrates that, among 329 metropolitan areas in the United States, blacks experience the greatest per capita pollution burden in 32.5% of metropolitan areas, Hispanics in 22.5% of metropolitan areas, followed by Pacific Islanders, Native Americans, Asians, and finally whites in just 4.3% of metropolitan areas.

To explain this intercity variation in total pollution and in the pattern of racial inequalities, research has targeted a few primary explanatory variables. The chief of these is racial residential segregation. Lopez (2002) offers evidence that white/black residential segregation affects neighborhood outcomes in a study of 44 metropolitan areas. Morello-Frosch and Jesdale (2006) found that highly segregated or extremely segregated metropolitan areas especially burden black and Hispanic residents. Downey (2007) and co-authors (2008) find a lesser role for residential segregation, and question the size of the effect evidenced by Morello-Frosch and Jesdale (2006). In the most comprehensive study on the topic to date, Ard (2016) studied nineteen different indices of black/white residential segregation, and found that most are associated with worse pollution outcomes for neighborhoods with more black residents. Using models that more closely account for spatial effects shows that common non-spatial indices, such as the popular dissimilarity index, weaken, but that other measures, such as measures of spatial clustering, remain important predictors. Together, these studies suggest a mixed effect for racial residential segregation, and point to how a spatial measure of segregation, like a clustering index, is stronger than other measures.

In addition to residential segregation, previous research outlines three other primary metropolitan factors that are theorized to be associated with environmental inequalities. First, Morello-Frosch and Jesdale (2006) descriptively suggest the possibility of an effect for racial income inequality, but Lopez (2002) and Downey et al. (2008) do not find evidence for it. Second, Ash et al. (2013) show that larger differences between the pollution burden of whites and of minorities in a metropolitan area affect the overall level of pollution in the city. Third, a racial inequality hypothesis would suggest that metropolitan areas with larger proportions of minority populations will have greater pollution in their neighborhoods; in this way, race may be a salient marker at geographic scales larger than just neighborhoods (e.g. Mele 2016). Downey (2007) found no effect for percent black or percent Hispanic, and Ard (2016) found that the proportion of African Americans in a metropolitan area is associated sometimes, but not consistently with greater neighborhood pollution.

2.1.2 Social Capital and Environmental Justice

How the civic milieu of metropolitan areas affect environmental inequality remains underexplored in the EJ literature, although this factor has been associated with many other social outcomes such as crime, corporate social responsibility, and health (Jha and Cox 2015; Kwon, Heflin, and Ruef 2013; Lee et al. 2015; Rupasingha, Goetz, and Freshwater 2006; Shoff and Yang 2013), and is integral to EJ theorizing (Pellow 2002; Taylor 2014). In EJ research, local pollution is understood through a perspective that emphasizes the linkages between advantaged and disadvantaged populations. This is particularly evident in writings on not-in-my-backyard (NIMBY) movements. It is not simply that neighborhoods prevent pollution in their own residential areas, but that the effect of preventing pollution has the equal and opposite effect of what Bullard (1990) calls PIBBY—"put-in-blacks'-backyards." Centered on these are two sometimes competing hypotheses of neighborhood outcomes in EJ research: that environmental discrimination operates to unequally site industrial facilities (Boone and Modarres 1999; Mohai and Saha 2007; Mohai and Saha 2015; Pastor, Sadd, and Hipp 2001), and the claim that minorities move in to less desirable areas once land values have dropped (Been 1994). As Bullard (1990) and others remind us (Mohai and Saha 2015a; Pulido 2000), however, intra-urban processes of siting and migration are not distinct, especially when considering how a city's urban form has developed historically (Boone et al. 2014; Elliott and Frickel 2015; Pellow 2002; York et al. 2014).

One possible way in which these processes of environmental inequality are sustained concerns the mechanisms through which an urban area as a system provokes or inhibits action for justice. One of the primary factors in Pellow's (2002) "environmental inequality formation" framework concerns how stakeholders limit the realm of possibility when it comes to the distribution of pollution. Put another way, local power players and relevant organizations sustain historical inequalities by putting the pollution where it has always gone, in neighborhoods with more people of color. Further, Rudel (2013) details how "defensive environmentalism" as the modal type of environmental movement are able to win victories at small geographic scales, but that these parochial movements do not scale up by bridging across places or associations to bring about greater change.

While EJ organizations offer a counterexample often focused on broader notions of justice beyond just a given neighborhood (Cole and Foster 2001; Rudel 2013; Pulido 2000; Stretesky et al. 2011; Taylor 2014), the wider proliferation of the defensive environmentalist dynamic operates similar to the NIMBYism long seen as underwriting environmental injustices and the continuity promised by stakeholders in environmental inequality formation.

Following previous social capital research that avers that social capital aggregated at large geographic units conditions social outcomes (Kwon, Heflin, and Ruef 2013; Paxton 2007; Rupasingha, Goetz, and Freshwater 2006), I argue that a social capital perspective can move EJ research from a narrower focus on the civic sum of environmental and place-based associations or pollution stakeholders to a wider focus on how organizational social capital affects environmental inequalities. The EJ-based association framework and broader social capital perspective operate through similar mechanisms. In both, networks of associations accrue the benefits of such networks in unequal ways.

Although social capital is often measured as an individual-level factor such as trust (Portes 2000), Putnam (2000) perceives the main benefits of social capital to democratic society at large, and often through associations (see also Coleman 1988). Organizations provide connections that bolster individual self-efficacy and spur democratic verve, including more involvement in the political process and enhanced possibilities for social change (Kwon and Adler 2014; Putnam 2000; Small 2009). Social capital organizations serve as clearinghouses through which ties, resources, and information are shared (Small 2009). In this way, organizations, themselves composed of individuals, are a critical conduit of social capital, and connote the strength of community in a more aggregated and closely conceptualized way than through an analysis of only individuals. While neighborhood-level urban research has shown that communities higher in collective efficacy and social capital are better off than their less well-organized counterparts (Sampson 2012; Small 2004), I move to a higher geographic level, the metropolitan area, to investigate how the accumulation of these organizations is associated with patterns of inequalities across places.

An important advance in social capital research methodologically distinguishes between “connected” and “isolated” social capital organizations, with implications for whom social capital benefits (Kwon, Heflin and Ruef 2013; Paxton 2007, 2002). Connected organizations have memberships that cross-cut with other associations. These are high on “bridging” social capital that is seen as essential to building a strong civil society (Putnam 2000). Members of isolated organizations, on the other hand, do not typically associate with other organizations. Isolated associations thereby exhibit mostly “bonding” social capital that offers intra-organizational benefits for members but not typically beyond the organization.

Research from sources such as the World Values Survey (Paxton 2007) and the Social Capital Community Benchmark Survey (Kwon, Heflin, and Ruef 2013) that utilize large samples have found that the average number of memberships held by group members in other organizations is patterned across organization types. For instance, political organizations and civic organizations have a higher average number of memberships in other voluntary organizations than religious organizations and sports clubs. The same relationship is found for the total proportion of members who are in other voluntary organizations. In Kwon, Heflin and Ruef's study, the average number of memberships in other organizations for a member of a political organization is 6.28, while the average number for a religious association is 3.76. In this way, a political organization would be categorized as a "connected" organization because the members of these groups have more cross-cutting ties. By contrast, a religious organization would be categorized as "isolated" because, on average, they do not have as many ties. Taken together, Paxton (2007) and Kwon et al. (2013) illustrate how a social capital index can be developed by counting the total number of organizations in a locale, and differentiating them into connected and isolated based on their organization type (e.g. civic, religious, etc.), which can be inferred based on previous research.

The implication for the aggregate effect of these organizations is that the presence of more connected associations in a city indicates that these urban dwellers have more and diverse ties through local organizations than a city with fewer connected associations. Metropolitan areas with more isolated organizations, similarly, have more social ties than those with fewer isolated organizations, but these ties are not as diverse or cross-cutting like ties from connected organizations; therefore, the benefits of the social capital accumulate to those within those organizations—and not to the wider community. In these ways, organizational social capital in connected and isolated organizations is an indicator of the pattern of cohesiveness and insularity across organizations within a city.

The implications for the distinction between connected and isolated organizations cut to the heart of questions of for whom social capital works, an important criticism of social capital research (Portes 2000). To date, though, most of the research that has analyzed community social capital without subdividing it into connected and isolated components has found it to be beneficial to social outcomes such as increased economic intergenerational mobility (Chetty et al. 2014), enhanced corporate social responsibility (Jha and Cox 2015), and improved health outcomes (Kim and Kawachi 2006).

By contrast, emerging research on urban areas in the U.S. using the connected and isolated distinction has found striking differences. Kwon, Heflin, and Ruef (2013) found that more isolated organizations are associated with lower rates of entrepreneurship in a community. More connected organizations increase entrepreneurship in a given place, but, importantly, minorities experience less of a benefit from connected organizations than whites. Audia and Teckchandani (2010) also find that connected organizations spur economic activity more generally in metropolitan areas, but isolated organizations hinder it. If connecting and isolating organizational social capital are indicators of cohesiveness and insularity in organizations within a city, the research above shows how these forms of social capital also connect and isolate populations across a diverse range of social outcomes.

Research on environmental inequalities investigates differences across places in social capital and civic capacity, but has not done so in a way that accounts for the connected and isolated conceptualizations. Primarily, this research finds that greater civic capacity in a place attenuates environmental degradation. Hamilton (1993, 1995) found that stronger voter turnout in counties is associated with a smaller likelihood of siting of hazardous waste facilities. Arora and Cason (1999) found limited support for the negative association between voting rates and environmental degradation, but that the relationship is particularly present in non-urban places in the southeastern United States. In research on non-profit organizations, Zahran, Hastings, and Brody (2008) detail how neighborhoods with more financial assets in non-profits were less likely to host a hazardous waste facility. Hispanic communities with environmental justice organizations are associated with greater attention from regulators in these communities (Konisky and Reenock 2013). Exposure to releases from toxic facilities is lessened in states where a greater percentage of residents are members of large pro-environmental organizations. Finally, Ard and Fairbrother (2016) illustrate that counties with more organizational activism and political participation tend to be located further from large toxic facilities, and that neighborhood-level racial inequalities are robust to the inclusion of social capital measures. Taken together, this research finds that social capital at relatively large geographic levels – most often counties – lessens exposure to environmental degradation in these places. At the same time, however, no research to date has distinguished between the bridging and bonding properties of social capital across places, and what the differential implications may be for exposure to environmental degradation.

Taking environmental justice theory on NIMBYism and defensive environmentalism as a starting point (Bullard 1990; Rudel 2013; Taylor 2014), I argue that investigating the relationship between metropolitan social capital and environmental inequality is a necessary step forward. Social capital links the cumulative effect of environment injustice as a dynamic that develops concomitant with a wider associational civic context that may accentuate or attenuate racial inequalities. Moreover, this wider civic milieu can be characterized as having two distinct components: "connecting" and "isolating" (Paxton 2007). Because of disparities across urban areas in the overall levels of air pollution (Ash et al. 2013), social capital may enable inter-urban inequalities, such that metropolitan regions with more connected associations have less pollution and those with more isolated associations have greater pollution. Finally, these distinctions may also have implications for racial inequalities. Metropolitan areas with more isolated organizations may also have not just more toxic air, but a more unequal distribution of toxic air. The relationship for connected organizations could be hypothesized in two directions. On one hand, urban areas with more connected organizations could increase social ties and organizational resources, thereby enhancing civic capacity across the metropolitan area and attenuating inequalities. On the other hand, as Kwon, Heflin and Ruef (2013) found in their study of entrepreneurship, the benefits of connected organizations may not accrue equally across a metropolitan area because of differential levels of access to these types of organizations, and thereby extend inequalities. Together, this leads to the following hypotheses:

> H1: Metropolitan areas with more isolated organizations will be associated with *higher* levels of industrially produced toxic air in their block groups.
>
> H2: Metropolitan areas with more connected organizations will be associated with *lower* levels of industrially produced toxic air in their block groups.
>
> H3: Metropolitan areas with more isolated organizations will be associated with *accentuated* inequalities in the levels of industrially produced toxic in block groups with greater proportion of black residents and Hispanic residents.
>
> H4A: Metropolitan areas with more connected organizations will be associated with *attenuated* inequalities in the levels of industrially

produced toxic in block groups with greater proportion of black residents and Hispanic residents.

H4B: Metropolitan areas with more connected organizations will be associated with *accentuated* inequalities in the levels of industrially produced toxic in block groups with greater proportion of black residents and Hispanic residents.

2.2. Data and Methods

The driving premise of the present study is that multiple levels conjoin to influence urban inequalities in exposure to toxic air pollution: one level is the metropolitan area as a whole, specifically how it is civically organized; the other level is the neighborhood, specifically its socio-demographic composition, controlling for other background factors. The aim is to assess if both levels indeed have an effect net of each other and, if so, how and in what ways.

2.2.1 Metropolitan Level Factors

The primary independent variables in the analysis concern the social capital of a metropolitan area. I utilize a modified form of social capital index created by Rupasingha, Goetz, and Freshwater (2006). In their widely used index (e.g. Chetty et al. 2014; Lee et al. 2015), Rupasingha, Goetz, and Freshwater (2006) use the U.S. Census' *County Business Patterns* to determine the density of social capital organizations in counties. They conduct a factor analysis of this density measure and four others, such as the voter turnout in the most recent presidential election, and the census response rate. Because research on and critiques of social capital find distinctions in the causal pathways between how individual and associational social capital operate (Paxton 2002;

Portes 2000), I choose to emphasize only the social capital organizations, and do not include the other components.

Following research on the different types of associational social capital (Audia and Teckchandani 2010; Kwon, Heflin, and Ruef 2013; Paxton 2007), I subdivide the social capital organizations into two groups: connected and isolated. I assign ten categories of the NAICS (North American Industry Classification System) codes of social capital organizations outlined by Rupasingha, Freshwater, and Goetz (2006), as well as two additional types, mainly concerning social welfare, suggested by other research (Paxton 2007). Organization types considered to be connected are: (1) civic and social associations, (2) business associations, (3) political organizations, (4) professional organizations, (5) human rights organizations, and (6) environment, conservation, and wildlife organizations. Isolated organizations include: (1) religious organizations, (2) sports, clubs, and managers, (3) fitness and recreational sports centers, (4) bowling centers, (5) golf courses, and (6) labor unions. Connected organizations have been demonstrated in large surveys to have bridging properties that increase the density of ties among organizations and their members across a place, and isolated organizations primarily have bonding properties that benefits group members and are more tied to their group, and not to other associations (Kwon, Heflin, and Ruef 2013; Paxton 2007).

Table 2.1 shows the mean, coding, and standard deviation of neighborhood and metropolitan area variables. Residential segregation is calculated using a Global Moran's I for the proportion minority in block groups in each metropolitan area. A Global Moran I is used to test if the block group's racial composition is spatially clustered. Varying from -1 to 1, values greater than zero denotes data that is clustered, values less than zero denotes data that is dispersed, and a statistic near zero denotes a random pattern. For this analysis, I use a queen-one contiguity matrix for the proportion of block group residents who are racial minorities (i.e. non-white) to test to see how clustered are adjacent block groups in terms of their racial composition. The queen-one contiguity approach takes into the spatial relationships between a given unit (i.e. a block group) and all of the units with which it shares at least a single boundary point. I use this clustering index of segregation instead of a measure of evenness because previous research indicates that evenness indices of segregation, such as the dissimilarity index, are weaker predictors than clustering indices (Ard 2016).[1] Of the 363 metropolitan areas in the contiguous United States, 352 have a statistically significant Global Moran's I for the proportion minority across block groups, ranging from 0.1 to 0.89. The 11 metropolitan areas that were not statistically significant were not included in the analysis.[2] Additional metropolitan

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[1] Supplemental regression models utilized two segregation measures of evenness instead of the Global Moran's I for proportion minority. The two measures are a Theil information index for (1) proportion white and proportion black, and (2) proportion white and proportion Hispanic. Each information index is used in a cross-level interaction with the associated block group racial composition measure (e.g. white/black information index and proportion black). Results are substantively similar. For analyses of toxic concentration, there is no statistically significant main effect for either measure, and the cross-level interaction is statistically significant and positive for proportion Hispanic but not for proportion black; these findings mirror those for the Global Moran's I.

[2] These metropolitan areas were likely not significant because each has a relatively small minority population (Hwang, Hankinson, and Brown 2015). These 11 metropolitan areas are: Missoula, MT; Coeur d'Alene, ID; Cumberland, MD-WV, Oshkosh-Neenah, WI; Columbus, IN; Parkersburg-Marietta-Vienna, WV-OH; Idaho Falls, ID; Eau Claire, WI; Redding, CA; Pocatello, ID; and Bangor, ME.

Table 2.1. Coding, mean, and standard deviation of study variables.

Variable	Coding	Mean	SD
Block Group Level			
Toxic Concentration	1.54e-5 to 6,516,901 (pounds of pollutants indexed to toxicity of chemicals)	6,946.23	52,909.05
Toxic Concentration, Logged	-11.08 to 15.69 (pounds of pollutants indexed to toxicity of chemicals)	6.91	2.39
Prop. Black	0 to 1	0.14	0.24
Prop. Hispanic	0 to 1	0.17	0.23
Median Household Income	0 (more than $50,000) to 1 (less than $50,000)	0.43	0.5
Prop. Manufacturing Workers	0 to 0.95	0.1	0.08
Median Commute Time	4 to 90 (in minutes)	23.65	8.38
Population Density	0.0005 to 1296.53 (residents per square kilometer, in thousands)	22.42	31.53
Metropolitan Level			
Population, Logged	10.92 to 16.76	12.71	1.07
Census Region			
East	12.5% of metropolitan areas		
South	40.63% of metropolitan areas		
Midwest	25.57% of metropolitan areas		
West	21.31% of metropolitan areas		
Prop. Black	0.002 to 0.52	0.11	0.11
Prop. Hispanic	0.007 to 0.96	0.13	0.16
Median Income, logged	10.48 to 11.39 (log of median income)	10.78	0.16
Residential Segregation	0.1 to 0.89 (Global Moran's I of proportion minority in metropolitan area's block groups)	0.53	0.19
Connected Social Capital	0.5 to 9.42 (connected social organizations per 10,000 residents)	2.21	1.18
Isolated Social Capital	1.54 to 15.68 (isolated social capital organizations per 10,000 residents)	8.98	2.73

Sources: 2008-2012 American Community Survey, 2012 Risk-Screening Environmental Indicators Geographic Microdata; 2012 *County Business Patterns*.
Block Group N=170,854. Metropolitan Level N=352.
Note: Study variables are group-mean centered (for block group measures) or grand-mean centered (for metropolitan level measures) for the analysis, and shown in this table before those transformations.

controls include the proportion black and the proportion Hispanic, which is employed to account for a potential racial inequality at the metropolitan level (Ard 2016). Census regions are utilized to see if pollution patterns are not structured by only neighborhood or metropolitan levels, but also regions (Ard 2015). Median income is included to denote the relative economic affluence of the metropolitan area (Ash et al. 2013); a log version is used to account for skew. Finally, the logged population is included to control for city size.

2.2.2. Block Group Level Factors

The unit of analysis for the neighborhood are census block groups, the smallest level at which information about the racial and socioeconomic composition of the neighborhood is available. The data on air quality are from the Environmental Protection Agency's (EPA) Risk-Screening Environmental Indicators Geographic Microdata (RSEI-GM) for the year 2012. I use the geographically aggregated data for RSEI Version 2.3.4. The RSEI-GM uses EPA Toxic Release Inventory (TRI) data that documents pollutants from more than 20,000 industrial facilities in the United States. Facilities meet the requirements for TRI reporting if they meet each of three criterions: employ at least 10 full-time employees, are within a specific industry sector such as manufacturing or mining, and manufacture or process greater than 25,000 pounds of a TRI chemical, and use more than 10,000 pounds of a TRI chemical in a given year. In 2012, more than 400 chemicals were utilized for the RSEI-GM data from more than 20,000 facilities.

To create the dependent variable, toxic concentration, the RSEI-GM uses TRI data to model the health risk posed by chemicals from large industrial facilities. The EPA utilizes plume modeling techniques that measure the fate of chemicals by accounting for the amount of the chemical, the toxicity of the chemical, the source of release (e.g. stack, valve), its transport through space, and the route's relation to human exposure (Environmental Protection Agency 2015). Facilities are located at the center of an 810 m^2 grid cell nested within a grid that covers the contiguous United States. All grid cells in a 49 kilometer radius of a facility are assigned a pollution value based on the likely pounds of releases indexed to the toxicity of the chemicals in that particular grid cell. The grid cells receive different values of this toxic concentration variable depending on the fate of the release of the pollutant. For instance, grid cells closer to the facility typically have a higher toxic concentration than those further away.

The block group toxic concentration is created by determining the proportion of the block group area that is covered by a grid cell, and aggregating the toxic concentration proportionally (see Ard 2015 for an example of this approach). For example, if a block group contains three grid cells with toxic concentration values of 500, 400, and 1,000, respectively, and the grid cells comprise 50 percent, 25 percent, and 25 percent of the area, respectively, the toxic concentration would be calculated by multiplying each grid cell's proportion and its toxic concentration value: ((500*0.5) + (400*0.25) + (1000*0.25)). The estimated toxic concentration for this block group is 600. Because the toxic concentration measure is highly skewed (see below; Collins, Munoz, and JaJa 2016), I log transform the variable.

The RSEI-GM has been used by researchers to predict environmental inequalities particularly for smaller levels of geographies (Ard 2015; Ard 2016; Ash and Fetter 2004; Ash and Boyce 2011; Ash et al. 2013; Boyce, Zwickl, and Ash 2016; Collins, Munoz, and JaJa 2016; Downey 2007; Downey et al 2008; Downey and Hawkins 2008; Zwickl, Ash and Boyce 2014). RSEI-GM is a major advance in measuring industrial air pollution from earlier environmental justice research that focuses on incidence of facilities, or the pounds of pollutant releases, without considering the toxicity of the chemicals at hand (e.g. Bryant and Mohai 1992; Pais, Crowder, and Downey 2013). Limitations of the data include that it focuses solely on large industrial facilities, and therefore misses the many small and medium-sized polluters that go unregulated by the TRI (Elliott and Frickel 2015). The RSEI-GM's use of industrial pollution data also does not measure other types of pollutants, such as those from transportation sources like the National Air Toxics Assessment (e.g. Liévanos 2015). Finally, while the data are one of the best tools with which to denote pollution data in neighborhoods, it is an estimation, not a direct measurement of neighborhood air quality.

Block groups were included from all metropolitan areas in the contiguous United States. Independent variables at the block group level were obtained using 2008-2012 American Community Survey (ACS) estimates. Block groups were excluded from the analysis if they had an estimated total working population less than 100. The exclusion of these block groups, in addition to using the five-year pooled data, helps to maximize the reliability of ACS estimates by minimizing the possible size of the margins of error for the estimates. A limitation of using five-year data (instead of 2012 or 2010-2012 estimates) is one of validity, as estimates are drawn from data across a larger period of time than that of the dependent variable.

The following independent variables at the block group level are included in the analysis. Race is measured by the proportion of blacks and proportion of Hispanics in a block group. Following Ard (2015), household median income is measured in two categories: less than or equal to $50,000, and greater than $50,000 (the latter is the reference category). Income is an important predictor as class has long been a focus of environmental justice research (Downey and Hawkins 2008). Proportion of manufacturing workers is often associated with greater pollution because this industrial class of workers is associated with environmentally risky work (Sicotte and Swanson 2007). Median commute time has been found to be a significant predictor in some studies such that longer commutes allow workers to find cleaner air (Liévanos 2015). The population density of the block group is also included, as places that are more densely populated may have more commercial activity and thereby possibly more pollution. All neighborhood measures are group mean centered within each metropolitan area, and all metropolitan covariates are grand mean centered.

2.3. Results

2.3.1 Descriptive Statistics

These data on toxic environmental exposure showcase dramatic differences between urban areas in the United States. Comparing the median block group toxic concentration for metropolitan areas, the median block group in a metropolitan area that is near the 75th percentile (in metropolitan areas such as Indianapolis-Carmel, IN, Pensacola-Ferry Pass-Brent, FL, Philadelphia-Camden-Wilmington, PA-NJ-DE-MD) has approximately *sixteen* times the toxic concentration as the median block group in a metropolitan area near the 25th percentile (in metropolitan areas like Orlando-Kissimmee-Sanford, FL, Sioux Falls, SD, and Springfield, IL). Table 2.2 shows the metropolitan areas with the highest median block group toxic concentration in 2012. The toxic concentration data is highly skewed: about seventy percent of all toxic exposure in metropolitan America is accounted for by just 10 percent of block groups. Table 2.2 also shows which metropolitan areas have the greatest number of these highly polluted block groups. The 10 metropolitan areas represented in the second column of Table 2.2 contain about a quarter of the total toxic concentration in air pollution in the United States.

The average number of connected social capital organizations per 10,000 residents in a metropolitan area is 2.21, and the average number of isolated organizations is 8.98 per 10,000 residents. Table 2.3 shows the 10 highest and 10 lowest metropolitan areas in connected social capital and isolated social capital. A metropolitan area one standard deviation above the mean in both social capital measures with a population of 1,000,000 residents would have approximately 273 more isolated social capital organizations and 118 more connected associations than a metropolitan area with the same population that is average in isolated and connected social capital. There is a sizable amount of variation: a metropolitan area with isolated social capital around the 25th percentile nationally has about 48.8 percent fewer isolated social capital organizations than one at the 75th percentile. The difference in connected social capital is larger. A metropolitan area in the 75th percentile in connected social capital has 84.6 percent more connected associations than one at the 25th percentile. Finally, these two metrics are moderately and positively correlated ($r = 0.27$, p value < 0.05), indicating that urban areas with more of one type of metropolitan social capital also have more of the other.[3]

[3] To test for a multiplicative effect of these two variables, I computed a model of metropolitan covariates with no cross-level interactions that included an interaction between the density of isolated organizations and the density of connected organizations. While the main effect of each remained significant, the interaction was not significant. This indicates that the differential effect evidenced in Model 2 in Table 2.4

Table 2.2 Metropolitan Areas with Greatest Industrial Pollution, 2012

Rank	Highest Median Neighborhood Toxic Concentration[a]	Most Neighborhoods Among Top 10 Percent Most Risky[b]
1.	Beaumont-Port Arthur TX (42,018.51)	Houston-Sugar Land-Baytown (2,140)
2.	Blacksburg-Christiansburg-Radford VA (41,972.83)	Chicago-Joliet-Napierville IL-IN-WI (1,822)
3.	Rockford IL (35,797.03)	Cincinnati-Middletown OH-KY-IN (1,243)
4.	Reading PA (33,371.96)	Cleveland-Elyria-Mentor OH (913)
5.	Wichita KS (33,052.68)	Los Angeles-Long Beach-Santa Ana CA (825)
6.	Anniston-Oxford AL (29,146.96)	New Orleans-Metairie-Kenner LA (625)
7.	Decatur AL (24,404.52)	Louisville/Jefferson County KY-IN (565)
8.	Houston-Sugar Land-Baytown TX (23,496.41)	Seattle-Tacoma-Bellevue WA (527)
9.	Cincinnati-Middletown OH (23,200.6)	Detroit-Warren-Livonia MI (491)
10.	Lima OH (22,818.58)	Baton Rouge, LA (409)

[a] Number in parentheses is the median neighborhood toxic concentration.
[b] Numbers in parentheses denotes the total number of block groups in top 10%.

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is not offset by a multiplicative effect on account of the moderate positive correlation between the two variables.

Table 2.3. Metropolitan Areas with Highest, Lowest Forms of Social Capital, 2012

Rank	Highest Connected Social Capital[a]	Lowest Connected Social Capital[a]	Highest Isolated Social Capital[a]	Lowest Isolated Social Capital[a]
1.	Bismarck ND (9.42)	Warner Robbins GA (0.5)	Danville VA (15.68)	Provo-Orem UT (1.54)
2.	Jefferson City MO (8.1)	Anderson SC (0.59)	Florence-Muscle Shoals AL (15.17)	Ogden-Clearfield UT (2.45)
3.	Springfield IL (7.56)	Ogden-Clearfield UT (0.66)	Kokomo IN (15.08)	Las Vegas-Paradise NV (2.64)
4.	Johnstown PA (6.07)	St. George UT (0.66)	Jackson TN (14.95)	Laredo TX (2.72)
5.	Casper WY (6.06)	McAllen-Edinburg-Mission TX (0.67)	Gadsden AL (14.76)	St. George UT (2.94)
6.	Topeka KS (5.83)	St. George UT (0.72)	Altoona PA (14.71)	Salt Lake City UT (3.19)
7.	Cheyenne WY (5.78)	Hanford-Corcoran CA (0.79)	Decatur IL (14.56)	Hanford-Corcoran CA (3.29)
8.	Harrisburg-Carlisle PA (5.63)	Rocky Mount NC (0.79)	Cleveland TN (14.48)	Merced CA (3.43)
9.	Washington-Arlington-Alexandria DC-VA-MD-WV (5.44)	Pascagoula MS (0.8)	Steubenville-Weirton OH-WV (14.36)	McAllen-Edinburg-Mission TX (3.46)
10.	Tallahassee FL (5.27)	Yuma AZ (0.81)	Sheboygan WI (14.21)	El Centro, CA (3.52)

[a] Number in parentheses is the number of organizations per 10,000 residents

3.2 Multilevel Analysis

Table 2.4 shows the multilevel regression predicting logged block group toxic concentration. In Model 1 in Table 2.4, all block group covariates are shown. Block groups with more Hispanic and black residents are exposed to greater toxic concentration. A 10-point percentage increase in the Hispanic population of a block group is associated with an increased predicted logged toxic concentration value by 0.13, and a 10-point increase in the black population is associated with an increased predicted toxic concentration value by 0.1, net of other predictors. Neighborhoods with incomes less than $50,000 have greater predicted toxic concentration values. Block groups with longer commutes have lower exposure to toxic air from industrial sources. The intra-class coefficient in this model indicates that approximately 79 percent of the variation in the dependent variable is accounted for at the metropolitan level. This statistic helps to indicate the relative predictive strength introduced at the cluster level, that is at the metropolitan level. This statistic is comparatively high because of the great differences in the amount of toxic air between metropolitan areas.

In Model 2 in Table 2.4, eight metropolitan covariates are tested alongside block group covariates from Model 1. For the primary independent variables, the two types of social capital organizations have countervailing effects: metropolitan areas with more connected organizations have block groups with lower toxic concentration values, and more isolated organizations are associated with higher toxic concentration in block groups. This affirms Hypothesis 1 and Hypothesis 2 about the metropolitan-level effects of connected and isolated organizations. Toxic air is not just segregated on an intra-urban basis, but also through inter-urban processes. One such process is in how less connected

Table 2.4. Regression Results for Multilevel Analysis of Block Group-level Toxic Concentration in Metropolitan U.S.

	Model 1		Model 2		Model 3	
Block Group Level						
Prop. Black	1.02	***	1.02	***	1	***
	(0.02)		(0.02)		(0.04)	
Prop. Hispanic	1.34	***	1.34	***	1.04	***
	(0.02)		(0.02)		(0.05)	
Median Income	-0.05	***	-0.05	***	-0.05	***
	(0.01)		(0.01)		(0.01)	
Prop. Manufacturing Workers	-0.02		-0.02		-0.04	
	(0.04)		(0.04)		(0.04)	
Median Commute Time	-0.01	***	-0.01	***	-0.01	***
	(0.00)		(0.00)		(0.00)	
Population Density, in thousands	0.007		0.004		0.004	
	(0.00)		(0.00)		(0.00)	
Metropolitan Level						
Population, Logged			0.66	***	0.66	***
			(0.15)		(0.15)	
Census Region (Southern ref.)						
East			0.34		0.34	
			(0.44)		(0.44)	
Midwestern			0.83	*	0.83	*
			(0.34)		(0.34)	
West			-0.33		-0.33	
			(0.4)		(0.4)	
Proportion Black			0.03		0.03	
			(1.48)		(1.48)	
Proportion Hispanic			-3.09	**	-3.09	**
			(1.03)		(1.03)	
Median Income, Logged			-0.75		-0.75	

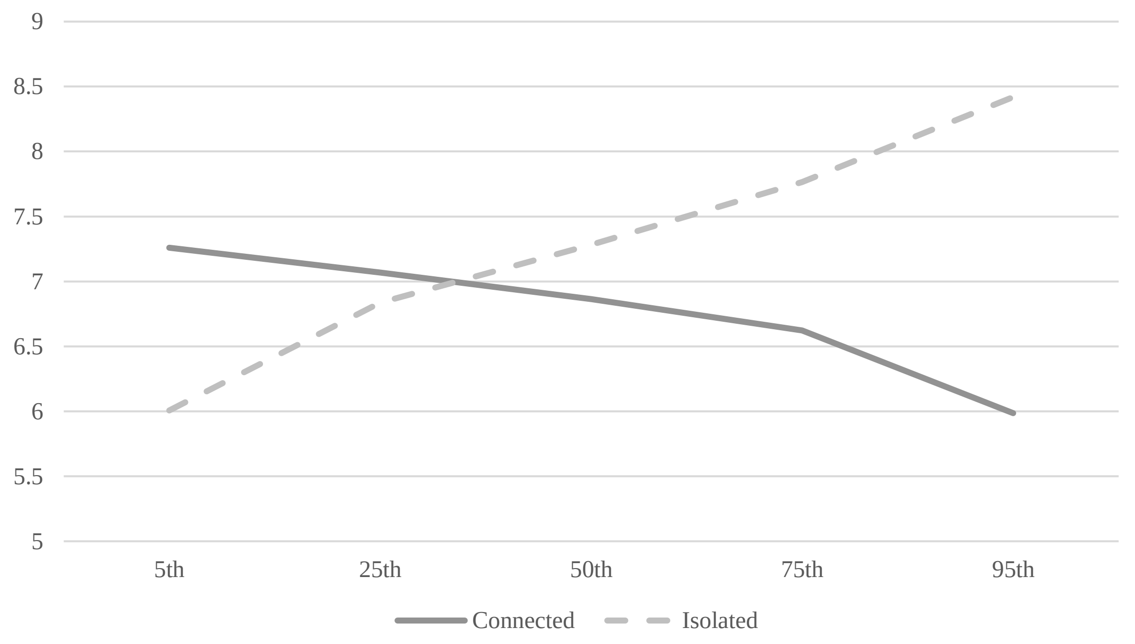
Residential Segregation		0.95		0.95	
		(0.83)		(0.83)	
Connected Social Capital		-0.37	**	-0.37	**
		(0.11)		(0.11)	
Isolated Social Capital		0.26	***	0.26	***
		(0.06)		(0.06)	
Cross-Level Interactions					
Residential Segregation x Prop. Black				0.26	+
				(0.15)	
Residential Segregation x Prop. Hispanic				1.77	***
				(0.17)	
Prop. Connected Social Capital x Prop. Black				0.07	***
				(0.02)	
Prop. Connected Social Capital x Prop. Hispanic				-0.13	***
				(0.03)	
Prop. Isolated Social Capital x Prop. Black				0.01	
				(0.01)	
Prop. Isolated Social Capital x Prop. Hispanic				0.06	***
				(0.01)	
Level-1 *N*	352	352		352	
Level-1 Variance	6.064	4.26		4.26	
Level-2 *N*	170,378	170,378		170,378	
Level-2 Variance	1.661	1.661		1.66	
Intra-Class Correlation Coefficient	0.785	0.719		0.72	

metropolitan areas suffer greater block group pollution, and through the negative effect that isolating organizations have in accentuating pollution. Figure 2.1 portrays the predicted values (from Model 3 in Table 2.4) of the main effect of each of these social capital variables on the block group's logged toxic concentration, and indicates large differences across different levels of social capital organization in metropolitan areas. An increase of one standard deviation in the density of isolated social capital organizations would be associated with an increase in the logged toxic concentration by 0.72, while such an increase for connected associations would be associated with a decrease in the predicted toxic concentration value, net of other factors, by 0.45.

For the control variables, the coefficient for proportion Hispanic is statistically significant and negative, indicating that metropolitan areas with more Hispanics have less air pollution from large industrial facilities. More populous metropolitan areas are found to have more air pollution in their block groups. Compared to block groups in Southern metropolitan areas, block groups in metropolitan areas in the Midwest have a higher toxic concentration. Residential segregation, median income, and the proportion of black residents in the metropolitan area are not statistically significant.

The final model (Model 3) in Table 2.4 adds the interaction terms to see if metropolitan covariates are correlated with accentuated or attenuated block group pollution for blacks and Hispanics. The findings are dependent on the racial composition measure under analysis. For block groups with more blacks, the interaction for isolated social capital is not statistically significant, but for Hispanics it is. The positive association for Hispanics indicates that block groups with more Hispanic residents experience greater pollution exposure in metropolitan areas with higher densities of

Figure 2.1: Predicted Values of Toxic Concentration (logged) by Percentiles of Connected and Isolated Social Capital Organizations



isolated social capital organizations. The findings for Hispanics supports Hypothesis 3, but the findings for black residents do not. For block groups that have 10 percent more Hispanics than their metropolitan average in metropolitan areas with isolated organizations one standard deviation below the mean (and holding all other measures constant at their means), the predicted toxic concentration value would be 6.69. If the metropolitan area is in a metropolitan area that is one standard deviation above the mean in the density of isolated organizations, the predicted logged toxic concentration is much higher, 8.15.

The interaction terms for connected social capital are statistically significant for block groups with black residents and for Hispanic residents. For neighborhoods with more Hispanic residents, metropolitan areas with more connected social capital are associated with less exposure to industrially produced toxic air. For neighborhoods with more black residents, more connected social capital is associated with *more* exposure to industrially toxic air. These are opposite findings for the interaction effects by the racial group under examination. In this way, the findings for the proportion Hispanic affirms Hypothesis 4A, and the finding for proportion black affirms the opposite hypothesis, Hypothesis 4B. Block groups with more Hispanic residents are associated with attenuated inequalities and those with a higher proportion of black residents are associated with accentuated inequalities in urban areas with more connected organizations.

The main effect of the clustering measure of segregation is not associated with block group toxic concentration. The interaction term, however, between residential segregation and proportion Hispanic is statistically significant and positive, meaning that neighborhoods with more Hispanics are associated with exposure to more toxic air in metropolitan areas that are more residentially segregated. The cross-level interaction for between residential segregation and proportion black is not statistically significant. For a block group with a Hispanic population 10 percent greater than the metropolitan average, the difference between the predicted logged toxic concentration value in a metropolitan area with a residential segregation value one standard deviation above the mean and one standard deviation below the mean is 0.43. This difference across the standard deviations is about sixty percent of the size of the differences evinced for one standard deviation of the main effect of connected social capital, and about a third of the size for that of main effect of isolated social capital.

2.4. Discussion and Conclusion

Using the most robust, fine-grained data on air quality from industrial sources in the United States, findings indicate support for environmental justice hypotheses that poor air quality is disproportionately a threat to blacks and Hispanics in the United States, and that social capital is associated with environmental inequalities. Following research on the countervailing effects of social capital organizations (Audia and Teckchandani 2010; Kwon, Heflin, and Ruef 2013; Paxton 2007), I subdivided a popular index of social capital associations into two components: connected and isolated organizations (Rupasingha, Goetz, and Freshwater 2006). The primary finding from this paper shows that a greater density of connected social capital organizations is associated with less toxic pollution exposure, and that, by contrast, a greater density of isolated social capital organizations is associated with more toxic air.

Findings from the present study indicate that there may be different contexts that produce pollution depending on the racial group in question. This aligns with what Grant et al. (2010:480) termed "recipes of emission outcomes" that show the confluence of neighborhood and facility attributes; to these, I add the importance of metropolitan area attributes. The primary metropolitan attributes of interest in this article are connected social capital and isolated social capital: neighborhoods are associated with inequalities in exposure to toxic air with each of these measures of the social composition of the urban area. These recipes also have metropolitan ingredients that are conditioned on the neighborhood racial composition. For Hispanic neighborhoods, the recipe for greater toxic air includes residing in an urban area with (a) more isolated social capital, (b) less connected social capital, and that is (c) more residentially segregated. For black neighborhoods, the recipe includes one metropolitan interaction ingredient: living in a metropolitan area with more connected social capital. Notably, none of the three metropolitan factors – both types of social capital as well as residential segregation – are associated with racial inequalities for blacks and Hispanics in the same way. Analyzing metropolitan factors in this way can both unlock how and why inter-urban differences in industrially produced toxic air has come to be, as well as why single-city studies evince different racial groups as the most environmentally disadvantaged (Downey 2007).

This study has some limitations which encourage further research. First, it uses a cross-sectional approach, and therefore is cautious about making causal claims. Second, while this study's use of industrial pollution data with the RSEI-GM is well-suited to its aims, it ignores other types of poor air quality from vehicular and household emissions, in addition to pollutants in water sources, as well as in the ground; further, it misses out on facilities that are not large industrial polluters (Elliott and Frickel 2015). Third, this study has taken up two metropolitan characteristics – residential segregation and social capital – and the cross-level interactions of each with racial composition of neighborhoods, but many other metropolitan characteristics are worth exploring, such as municipal government characteristics or socioeconomic makeup. Additionally, investigating the experiences of minority populations outside of that of blacks and Hispanics is an important task in environmental justice research, as is the study of other social groups, such as immigrants (Downey et al. 2008; Liévanos 2015). Finally, subdividing connected and isolated organizations is an approach that has not been used for the index pioneered by Rupasingha, Goetz, and Freshwater (2006), and other researchers may find this methodological approach useful.

Sites of economic agglomeration, metropolitan areas are the places where a vast majority of pollution in the U.S. is produced, and where the inter-urban and intra-urban patterns of pollution are highly unequal. This study highlights the need to integrate a discussion of the social organization of communities into environmental inequality research that has studied historical discrimination in facility siting, residential markets, and organizational characteristics of facilities. Studying the interrelation of these factors through metropolitan analyses of environmental inequality is a critical site for social scientific research.

CHAPTER THREE: RELIGIOUS ORGANIZATIONS, SOCIAL CAPITAL, AND INEQUALITIES IN EXPOSURE TO INDUSTRIAL POLLUTION IN THE UNITED STATES

Exposure to industrial pollution is conditioned by a diverse range of stakeholders in business, government, and community organizations that unequally segregate pollution (Bullard 1990; Pellow 2002). Research in the environmental justice tradition has long shown how local civic organizations in particular both fight environmental injustices on the most burdened end of the spectrum and maintain clean environments in the most affluent areas (Kurtz 2003; Anguelovski 2014; Martinez-Alier et al. 2014; Čapek 1993; Mele 2016). Little research, however, has attempted to systematically compare civic capacity and environmental degradation across urban areas (Ard and Fairbrother 2016; Hamilton 1995).

One prominent way in which civic capacity and community are evinced in the United States are through religious organizations (Bellah et al. 1985; Putnam 2000).[4] Membership in religious organizations proffers connections within and beyond organizations that creates possibilities for social action. More specifically, previous scholarship has identified uneven levels of community connections across different types of organizations. For example, Mainline Protestant congregations and Catholic parishes are often associated with increased emphasis on civic involvement and thereby more

[4] In this paper, “religious organizations” and “religious congregations” are used interchangeably. The guideline for defining a religious congregation in the data employed in this study is discussed further in the methodology section, and is consistent with the concept of an organization.

"bridging" ties between members and the wider community, while Evangelical churches are more likely to be characterized by "bonding" ties that unite group members but do less to connect to the wider community. Taken together, the cumulative effect of these bridging ties or bonding ties as seen through organizations conceptualizes the density of social ties in a place, and, further, is part and parcel of the capacity for social action of an urban area.

Integrating these insights on religious organizations, this study tests to see if a greater presence of three types of religious organizations as well as a composite measure of religious organizations is associated with air quality form industrial polluters in neighborhoods and metropolitan areas in the United States. This study has two primary aims. The first is to theoretically outline and empirically investigate the possibility that civic capacity in metropolitan areas may be linked to industrial pollution outcomes. The goal of doing so is to better articulate the mechanisms at play in the production of dangerous unhealthful toxins from industrial facilities. By using data on organizations across a metropolitan area instead of data on direct contestations of certain facilities, I move the analysis away from a confining conceptualization of directly implicated action to a perspective that emphasizes the more general social character of place, and how that relates to how social actions sustain, tolerate, or challenge environmental degradation and social inequalities.

The second primary aim is test how religious organizations, in a composite measure and also with distinct measures of specific religious traditions, are a vehicle for this civic capacity, and therefore might be related to industrial pollution. A guiding principle of this empirical approach is to emphasize how social capital organizations are conduits for “bridging” social ties across communities and “bonding” social ties within segmented organizations. The differential impacts of these two types of ties – as seen through three different types of congregations in Evangelicals, Mainline Protestants, and Catholics – is analyzed in conjunction with metropolitan disparities in industrial pollution as well as patterns of racial inequalities within urban areas. The purpose of examining these different ties is to explore not just how the social character of place shapes environmental outcomes, but how it may do so through differential pathways, and with differential implications for racial inequalities.

3.1 Literature Review

3.1.1. Connecting Community and Environmental Justice

Environmental justice research demonstrates the inequalities in exposure to environmental burdens across places, particularly finding that these disparities are differentially driven by race (Collins et al. 2016; Grant et al. 2010; Mohai et al. 2009; Taylor 2014). Research often centers on competing hypotheses of whether these inequalities are created more by racial discrimination in the siting of hazardous facilities, or that polluted areas attract minorities with lower land values (Crowder and Downey 2010; Been 1994; Mohai and Saha 2015a). While research generally ascribes racial environmental inequalities to the former explanation (Mohai and Saha 2015b), these lines of research leave aside other considerations, like historical patterns of land use (Elliott and Frickel 2015; Pulido 2000; Sicotte 2016; York et al. 2014), the organizational attributes of polluters (Grant et al. 2010; Collins et al. 2016), and the role that community organizations play in the unequal distribution of pollution (Ard and Fairbrother 2016; Bullard 1990; Hamilton 1995; Pellow 2002).

Civic capacity is one such way in which environmental inequalities are shaped, and a focus on civic capacity highlights the institutional dimensions of environmental inequality (Downey 2015). Within a metropolitan area, this can occur in both formal and informal ways. More formally, communities subject to environmental ills sometimes organize to contest injustices. Environmental justice research has long shown the agency, albeit constrained, of communities contesting unequal siting of hazardous facilities, (Anguelovski 2014; Blum 2008; Čapek 1993; Kurtz 2003; Pellow 2002). Less directly, some quantitative environmental justice research explores how the social capital of communities is associated with differential levels of environmental degradation. Higher rates of voter turnout in a county is associated with fewer hazardous waste facility sites (Hamilton 1993; Hamilton 1995), as are neighborhoods with more non-profit financial assets (Zahran, Hastings, and Brody 2008) or with environmental justice organizations (in Hispanic neighborhoods only; Konisky and Reenock 2013). At the same time, these relationships might be present depending on the region being studied (Arora and Cason 1999). Ard and Fairbrother (2016) measure social capital across neighborhoods in the United States, finding that minority communities do not necessarily have less social capital, and that this therefore does not shape neighborhood inequalities. At the county level, though, places with greater political participation and organization activism are characterized by being located near fewer toxic facilities (Ard and Fairbrother 2016).

A possible and important implication of social capital operating at multiple scales raises the issue of scalar disjuncture. For instance, a metropolitan area with strong civic capacity might enable environmental benefits for some neighborhoods, but the privileges gained by these neighborhoods could lead to the exploitation of other neighborhoods, thereby engendering wider inequalities for the metropolitan level overall. In this way, the cumulative effect of civic capacity at this larger scale is not the sum of its parts, but rather the division of its parts. This perspective can be characterized as a form of "defensive environmentalism" (Rudel 2013). The defensive environmental framework theorizes that the ability of community to successfully contest environmental issues at one scale most often directs pivotal energies away from environmental issues at a greater scale, such as that of global climate change. This perspective suggests that civic capacity at one level – such as with not-in-my-backyard organizations keeping pollution out of affluent neighborhoods – extends inequalities across a metropolitan area that disproportionately expose less affluent neighborhoods to more toxic air.

This perspective contrasts with the three other frameworks used in the study of metropolitan disparities in industrial pollution. The first framework concerns spatial inequality, averring that urban areas that are more residentially segregated are also more industrially polluted. While Morello-Frosch and Jesdale (2006) find a relationship between residential segregation and levels of pollution, Downey (2007) argues that this effect is relatively weak (see also Downey et al. 2008). With the most comprehensive study to date, Ard (2016) found that some residential segregation measures, such as popular measures of evenness (like the dissimilarity index), were not consistent predictors like directly spatial measures were linked. The second framework concerns material inequality, particularly by race. Racial income inequality was found not to be associated with metropolitan industrial pollution inequalities (Downey 2007), and median income had a curvilinear relationship at the metropolitan level (Ash et al. 2013). Finally, the overall levels of pollution have been shown to be correlated with relatively attenuated racial inequalities in exposure (Ash et al. 2013). Taken together, these studies suggest some relationships for the overall level of pollution and median income of the urban area, but mixed findings for key variables of interest, like residential segregation and racial income inequality.

3.1.2 Religious Organizations and Social Capital

Religious organizations are a primary institution through which social capital is produced as well as a primary conduit of social capital in the United States. Social capital, for the purposes of this study, can be defined as the sets of social ties that link together individuals and organizations within communities (Coleman 1988; Paxton 1999; Putnam 2000). Organizations are key to this, and this study is particularly interested in organizations as opposed to individuals. As Small (2009) argues, foregrounding organizations invokes the structure of the networks of individuals ties, but also moves beyond those networks by assessing the contextually dependent institutions in which those networks lie. In this way, organizations provide crucial linkages between people as well as provide capacity, norms, and infrastructure that sustain and build social capital.

In American public life, religious organizations in particular comprise a key vector of civic participation and community in social life (Ammerman 1997; Bellah et al. 1985; Becker 1999; Putnam 2000). Research on the density of religious organizations in a geographic area often focuses on how it is associated with better social outcomes, such as with crime (Goetz, Rupasingha, and Loveridge 2012), civic participation (Driskell, Lyon, and Embry 2008; Greeley 1997), education (Israel, Beaulieu, and Hartless 2001), and health (Lee 2010; Maselko, Hughes, and Cheney 2011), among other areas of analysis. This is a parallel emphasis to studies (see above) on social capital and industrial pollution that either find a positive benefit or no association in either direction (Ard and Fairbrother 2016; Arora and Cason 1999; Hamilton 1993; Hamilton 1995; Konisky and Reenock 2013; Zahran, Hastings, and Brody 2008).

A limitation of this approach, though, is that it considers religious organizations as a monolith by masking the diversity across types of religious organizations by subsuming them under a single measure. But the nature and type of ties within an organization often varies by organization type. Social capital researchers denote these differences in the nature of ties with the useful heuristic of "connected organizations" and "isolated organizations" (Paxton 2007). Organizations are classified in one type of organization or the other based on the average number of ties that group members have within that organization, to other organizations, and to the community at large (Coffé and Geys 2007; Paxton 2007; Kwon, Heflin, and Ruef 2013). For example, if the average organization member has a number of cross-cutting ties outside of the organization, then the organization might be considered a connected organization. By contrast, if the organization members are primarily linked to one another – and less so with the outside community – then this organization would be denoted an isolated organization. In these previous studies, religious organizations have generally have fewer cross-cutting or "bridging" ties, but more intra-organizational or "bonding" ties. They have been therefore classified as isolated organizations (Paxton 2007; Kwon, Heflin, and Ruef 2013).

Although the connected and isolated concepts are useful in distinguishing between different types of organizations, considering the many kinds of religious organizations underneath a single measure may artificially cover up variability by the type of religious organization. While each type of organization exhibits social capital, the nature of the ties diverges when it comes to whether they are most characterized by "bridging" or "bonding" properties. For example, Evangelical Protestants participate more in activities centered within their organization compared to other major faith traditions in the U.S., while Mainline Protestants and Catholics are more likely to engage in pursuits directed toward the wider community (Beyerlein and Hipp 2006b; Iannaccone 1994; Wuthnow 1999). For Evangelical organizations, the social ties are primarily bonding ties that connect group members to each other. This is often for tasks within the organization, such as volunteer work to improve church infrastructure (Hoge et al. 1998; Wilson and Janoski 1995; Wuthnow 1999).

More than this, Evangelical congregations are organizational conduits through which individualist viewpoints on race and social structure are foregrounded (Emerson and Smith 2000; Tranby and Hartmann 2008). Specifically, Evangelicals utilize a cultural tool kit reliant on a free market ideology that minimizes race as a social issue. It may be the case that urban areas with more Evangelical congregations would be linked to greater environmental degradation because of a widely held free market ideology that supports economic outputs even at great environmental cost. Moreover, racial inequalities may be more extensive in such places because less attention is paid to the structural causes of the formation of racial environmental inequality.

By contrast, social ties in Mainline Protestant and Catholic churches often extend beyond the congregation itself, thereby having bridging properties that connect to the wider community. In practice, it means that adherents of these groups do more volunteer work in the community, participate in other non-religious community organizations, or are more trusting (Iannaccone 1994; Welch, Sikkink, and Loveland 2007; Wuthnow 1999). Because of this, Mainline Protestant and Catholic organizations might be thought of more of a connected organization, at least in comparison to the isolated characterization of Evangelical organization.

The implication for these ties suggests that social outcomes will vary according to the levels of bonding and bridging social capital in communities. Beyerlein and Hipp (2005) found that counties with more Evangelical adherents had higher crime rates, but that counties with more Mainline Protestants and Catholics were associated with less crime. Blanchard et al. (2008) found that mortality was similarly linked with religious organizations by finding the same bonding and bridging split by the congregational type across counties. Shihadeh and Winters (2010) find that in new immigrant destinations for Hispanics, the rate of violence is highest in places with more Mainline Protestants but fewer Catholics (see also Harris and Feldmeyer 2015). Other studies have linked these distinctions to gambling (Eitle 2011), teen birth rates (Ovadia and Moore 2010), and residential segregation (Blanchard 2007), among others.

3.1.3. Religious Organizations and Environmental Inequality

Connecting the environmental sociological perspective on the scalar disjuncture of civic capacity to scholarship on the bridging and bonding properties of religious organizations can be synthesized theoretically and tested empirically. There is a critical research gap in how religious organizations, as important social capital organizations, are connected to the production and contestation of environmental inequality. Discussions of the intersection of the religion and the environment are primarily confined to studies of environmental beliefs (e.g. Peifer et al. 2016; Sherkat and Ellison 2007), while discussion of social capital and the environment typically assumes social capital as a monolithic social good (Hamilton 1995; Ard and Fairbrother 2016). The link between industrial pollution and religious organizations may not be immediately intuitive: most religious organizations probably do not interface directly with the location or emissions of large industrial facilities. But research on social capital organizations would suggest that the web of social relations undergirding a community influences social outcomes across those communities (Beyerlein and Hipp 2005; Blanchard et al. 2008; Paxton 2007; Putnam 2000).

A perspective examining environmental inequality extends this further by theorizing that these organizations are implicated in the assessment of any collective action problem, such as the contestation or tolerance of environmental degradation. One implication of this is that the focus on the formal contestation of environmental degradation in environmental justice may be artificially narrow. Analyzing bridging and bonding properties of varying densities of ties across religious organizations provides for an examination of the more fundamental character of social life in a given place. This deep backdrop of civic capacity is theorized to underwrite the possibility of social action in a place, including the constraint or inhibition of social action. It also directly relates to racial inequalities: the degree of inequality in a place would also be connected to the depth and type of community social capital that sustains historical levels of inequalities. It also connects to how greater or lesser presence of types of organizations, like Evangelical organizations, promote or inhibit free market ideologies that condition differential levels of pollution.

3.2. Data and Methods

The analysis centers on social capital as powered by religious organizations, and how it is or is not linked to differentials of levels of industrial pollution. Using multilevel models that can account for effects at both the metropolitan and neighborhood level, the analysis is also focused on how religious organizations may be associated with racial inequalities in exposure to unhealthful toxins. In doing so, the broader goal is to study how civic capacity in metropolitan areas connects to industrial pollution, particularly through different types of religious organizations.

3.2.1 Metropolitan Level - Independent Variables

Data for the primary independent variables in the study are drawn from the U.S. Religion Census' Religious Congregations and Membership Study (RCMS) for metropolitan areas. The data was collected by the Association of Statisticians of American Religious Bodies (Grammich et al. 2012). RCMS uses the *Yearbook of American and Canadian Churches* as its sampling frame, and primarily contacted national offices of religious organizations to obtain data. The data provides information on the number of congregations and the number of adherents for each religious denomination as well as what U.S. county in which the congregation is located. According to the RCMS, the definition of a congregation is "…a group of people who meet regularly (typically weekly or monthly) at a pre-announced time and location" (ASARB 2012). This definition is consistent with the concept of an organization (Small 2009). Data were collected on the congregations and adherents from 236 different religious denominations, and summary measures are provided in the data for the number of congregations that fall under the aegis of a certain family of denominations, like Evangelical and Mainline Protestant congregations, among others. An analysis of the RCMS data compared to other major sources of data on American religions indicate that the data is reliable compared to these other datasets, particularly so for the measurement of Christian congregations (Lim 2013).

Four primary independent variables at the metropolitan level are the density of (1) Mainline Protestant Congregations, (2) Catholic congregations, (3) Evangelical congregations, and (4) the total of Mainline Protestant, Catholic, and Evangelical congregations. The density is calculated by dividing the count of each type of congregation by the metropolitan area population, and multiplying by 10,000 to obtain the total number of congregations per 10,000 residents of a metropolitan area. Using organizations for the primary analysis is an effective strategy because organizations are both the sum of the individual social ties within them as well as host extra-individual benefits like organizational resources and capacity that serve as the critical conduits of social capital (Small 2009). For a supplemental analysis, though, I use data on the number of adherents of each of these types of religious organizations that is also provided by the RCMS. Rates are calculated for the number of adherents by dividing the number of adherents for each of the four groups (see above) by the 2010 population of the metropolitan area. This supplemental analysis is used to confirm or contradict the robustness of the findings for organizations.

Additional metropolitan covariates add integral control measures that might condition disparities in industrial pollution across metropolitan areas. These variables are from the decennial 2010 U.S. Census and the 2006 to 2010 American Community Survey. These data are also utilized for the tract-level variables. Residential segregation is measured using a Global Moran's I for each metropolitan area in the analysis. Previous research suggests that spatial measures of residential segregation are better predictors of environmental inequality than other measures of residential segregation, such as the more commonly used measures of evenness (Ard 2016). The Global Moran's I is a test of the relative clustering or dispersion across spatial units for a value, in this case the proportion in a tract that is black or Hispanic. I use the proportion black or Hispanic to connote the levels of segregation between whites and the country's two largest minority groups. I combine the two groups to avoid problems in metropolitan areas that have a low proportion of one group or the other. The test utilizes a queen-one, row standardized contiguity matrix which uses the average racial composition of adjacent tracts as the basis for the statistic. Metropolitan areas where adjacent tracts are highly similar in their racial composition are considered clustered. The statistic varies from -1 to 1, with values toward -1 denoting relative dispersion, those closer to 0 denoting relative randomness, and 1 denoting clustering. Other metropolitan attributes include the proportion black and Hispanic to account for racial inequality across metropolitan areas (Downey et al. 2008). Census regions are included as a dummy variable, with the East as the reference category

(Ard 2015). The population size of the metropolitan area is included as a covariate, as larger cities are often associated with more environmental degradation.

3.2.2. Tract Level – Dependent Variable

The unit of analysis in these multilevel models is the census tract. To measure exposure to environmental degradation, I turn to the U.S. Environmental Protection Agency's Risk-Screening Environmental Indicators Geographic Microdata (RSEI-GM). The RSEI-GM utilizes Toxic Release Inventory (TRI) data on large, heavy polluting industrial facilities to measure the health risks across small-scale geographies from chemical air emissions. Using a GIS, the RSEI-GM measures the plume, fate, and decay of the emissions across space. Each industrial facility from the TRI is plotted at the center of an 810 m^2 square grid cell that is part of a national grid of equal size cells across the contiguous United States. The estimates for the chemical emissions are made for each grid cell within a 49 kilometer radius of the facility. The total amount of releases indexed to the toxicity of the chemicals for human health is calculated for each grid cell, and denotes the "toxic concentration" of that area.

Using these grid cells as building blocks, the values are proportionately allocated to arrive at toxic concentration values for census tracts. For example, consider a census tract that is comprised of three grid cells, with each grid cell composing 50 percent, 25 percent, and 25 percent of the area. The toxic concentration for these grid cells is, respectively, 500, 800, and 600. The estimated toxic concentration for the tract is determined by multiplying the grid cell toxic concentration value by the percent of the tract that is comprises. In this example, the toxic concentration would be 600; the equation would be (500*0.5)+(800*0.25)+(600*0.25) = 600.

The RSEI-GM is one of the most robust sources of industrial pollution data in the United States, particularly because of how the data accounts for spatial relationships and because it indexes chemicals to their toxicity to human health. It is not without limitations. One limitation is that the TRI data on which it is based only includes large, industrial facilities that meet certain thresholds for regulation by the EPA. Emissions from small or medium-sized facilities are not accounted for with the data, although these facilities may contribute a sizable percentage of pollution (Elliott and Frickel 2015). Another limitation is that the RSEI-GM data only measures industrial pollution. This leaves aside other air pollutants, such as from transportation sources or household emissions, as well as other types of pollution in water and land. While this decision is intentional as industrial pollution is more closely conceptualized than a more general measure of air pollution, it nonetheless does not cover all the potential health risks from air pollutants in the United States.

3.2.3. Tract Level – Independent Variables

Several independent variables at the tract level are employed in the analysis. First, the proportion minority, composed of the proportion black and the proportion Hispanic, at the tract level is included to test for racial inequalities across neighborhoods in the United States. Previous studies indicate that these two populations are disproportionately exposed to environmental degradation (Downey 2007). Second, the median income is included to test for class differences, and includes a square term to account for potential curvilinear relationships seen in some environmental justice studies where the most disadvantaged places are working-class neighborhoods when compared to poorer or middle-class neighborhoods (Downey and Hawkins 2008). Third, the proportion of owner-occupied homes denotes the defensiveness of place from homeowners, as well as an indicator of wealth as home ownership is an important conduit of wealth in the United States (Rudel 2013). Fourth, the proportion of the employed population in manufacturing occupations controls for the fact that these workers often live in or near heavy polluting industrial facilities (Elliott and Smiley, Forth.; Sicotte and Swanson 2007). Fifth, the population of the tract is controlled for how population size may be related to pollution exposure. To ensure validity in the estimates of the tract-level measures that utilize data from the American Community Survey, tracts were not included in the analysis if they had an employed population fewer than 100. The final total of tracts in the analysis is 57,781 in 363 metropolitan areas.

The analysis below will first analyze descriptive statistics, particularly between metropolitan areas in their levels of toxic concentration and in religious congregations. The multilevel analysis that follows will employ five models. Model 1 includes tract-level covariates only. Models 2 and 3 examine a variable for the total number of religious organizations in a metropolitan area as well as interaction between that variable and tract racial composition. Models 4 and 5 are the primary models in the analysis in that they test three types of religious organizations, and, in Model 5, test how each is associated with industrial pollution with cross-level interactions with the tract-level racial composition measure.

Table 3.1. Coding, mean, and standard deviation of study variables.

Variable	Coding	Mean	SD
Block Group Level			
Toxic Concentration	0 to 30,600,000 (pounds of pollutants indexed to toxicity of chemicals)	8,821.49	140060.9
Toxic Concentration, Logged	-17.67 to 17.24 (pounds of pollutants indexed to toxicity of chemicals)	6.89	2.48
Prop. Black and Hispanic	0.002 to 1	0.33	0.3
Median Household Income	2.49 to 250	58.45	28.48
Median Household Income (square; in thousands)	6.25 to 62500.5	2799.47	4740.15
Prop. Manufacturing Workers	0 to 1	0.1	0.07
Prop. Owner-Occupied Homes	0 to 1	0.63	0.23
Population	105 to 37,452	4,359.17	1989.48
Metropolitan Level			
Census Region			
East	12.4% of metropolitan areas		
South	39.67% of metropolitan areas		
Midwest	25.9% of metropolitan areas		
West	22.04% of metropolitan areas		
Prop. Black and Hispanic	0.02 to 0.96	0.24	0.17
Median Income (in thousands)	31.26 to 86.29	48.83	8.2
Residential Segregation	-0.15 to 0.89 (Global Moran's I with possible values from -1 to 1)	0.52	0.21
Total Congregation Rate	0.72 to 22.65 (number of Evangelical, Mainline Protestant and Catholic congregations per 10,000 residents)	10.26	4.31
Evangelical Congregation Rate	0.49 to 18.48 (number of Evangelical congregations per 10,000 residents)	6.88	3.47
Mainline Protestant Congregation Rate	0.13 to 11.35 (number of Mainline Protestant congregations per 10,000 residents)	2.73	1.74
Catholic Congregation Rate	0.05 to 3.9 (number of Catholic congregations per 10,000 residents)	0.65	0.53
Population (logged)	10.92 to 16.75	12.68	1.06

Sources: 2010 Census; 2006-2010 American Community Survey, 2010 Risk-Screening Environmental Indicators Geographic Microdata.
Population: 58,781 census tracts. 363 Metropolitan Areas.
Note: Tract-level variables are group-mean centered (for block group measures), and shown in this table before those transformations. Metropolitan-level variables are grand-mean centered, and shown in this table before those transformations.

3.3. Results

3.3.1 Descriptive Statistics

Exposure to industrial air pollution in the United States is highly unequal. The mean toxic concentration for tracts in this analysis is 8,835.79, and the median is 1,226.65. This large difference shows the strong rightward skew of the toxic concentration measure. (This skew is partly accounted for in the statistical models by using a log of the dependent variable). Tracts at the 75th percentile of the toxic concentration value (value = 4747.16) are nearly sixteen times more toxic than those at the 25th percentile (value = 298.2). These differences are especially seen in the upper five percent of the data, which account for approximately two thirds (65.4 percent) of the industrial pollution in metropolitan areas in the United States. Moreover, these differences at the top are structured by metropolitan area. Of the 363 metropolitan areas in the data, 232 do not have any census tracts among the most toxic five percent in the United States. Half of the remaining 131 metropolitan areas (66 urban areas) do not have more than five such tracts. Twelve metropolitan areas have more than half of their tracts in the worst five percent. For example, all eighty-four census tracts in Rockford (Illinois) rank among the nation's highest five percent in health risks from industrial pollution. The Chicago-Napierville-Elgin metropolitan area has the most such tracts in the United States in 2010 (450 total, or 20.3 percent of the tracts in Chicago). These statistics illustrate the profound inequalities in exposure to toxic air, especially how these inequalities are shaped by the metropolitan area in which one resides.

The United States generally has high rates of adherence to Christian faith traditions, especially when compared to other religions in the country. These rates, however, vary greatly across metropolitan areas, and by the type of religious organization. The average number of religious organizations (that are either Evangelical, Mainline Protestant, or Catholic) in a metropolitan per 10,000 residents is 10.26 with a standard deviation of 4.31. In a metropolitan area with one million residents, an urban area one standard deviation above the mean in the density of religious congregations would have 862 more religious congregations than an urban area that is one standard deviation below the mean. These metropolitan areas one standard deviation above the mean have more than double the number of religious congregations than those one standard deviation below.

The differences across metropolitan areas for each type of religious organization are even larger than those for the total number of congregations. A metropolitan area one standard deviation above the mean in Evangelical congregations has three times the number of churches per 10,000 residents than in a metropolitan area one standard deviation below. The difference between one standard deviation above and below for Mainline Protestants is a more than a factor of four. The rate of Catholic churches is similar: there are nearly three times more Catholic parishes per 10,000 residents in a metropolitan area at the 75^{th} percentile than one at the 25^{th} percentile. These three measures are also all moderately correlated with one another, although not necessarily in the same direction. The density of Mainline Protestant congregations is positively correlated with Evangelical congregations ($r = 0.32$; $p < 0.05$) and Catholic congregations ($r = 0.27$; $p < 0.05$). The correlation between Evangelical congregations and Catholic churches, however, is negative ($r = -0.32$; $p < 0.05$). In all, these descriptive statistics about congregations show that there are large differences across metropolitan areas.

3.3.2. Multilevel Analysis

Model 1 in Table 3.2 shows all tract-level variables, and does not include metropolitan level measures. The association between proportion of black or Hispanic residents and toxic is positive and statistically significant. Tracts with more black and Hispanic residents than their metropolitan average are exposed to more toxic air. This finding echoes environmental justice research by finding evidence for racial inequality across neighborhoods in the United States. The relationship for income and its squared term is curvilinear. Findings for home ownership show that places with more owner-occupied homes are associated with fewer health risks from industrial pollution. Neighborhoods with more manufacturing workers and fewer residents are associated with more toxic air. These findings at the tract level vary slightly in effect size but are otherwise consistent across all models.

Model 2 and Model 3 investigate the density of religious organizations as a composite measure. In Model 2, the total number of religious organizations is positive associated with more toxic air, and is statistically significant. This means that a higher density of the total of Evangelical, Mainline Protestant, and Catholic congregations in a metropolitan area is associated with greater health risks from industrial pollutants for tracts within that metropolitan area. Model 3 adds an interaction term between the racial composition measure and the density of religious organizations. The statistically significant coefficient is positive. Tracts with a greater proportion of black and Hispanic residents are associated with more industrial pollution exposure in metropolitan areas with more religious organizations compared to those with fewer such organizations. These findings support previous research that links religious associations as isolated organizations that are associated with worse social outcomes (e.g. Kwon, Heflin and Ruef 2013; Paxton 2007).

A primary aim of this paper, however, is to decompose aggregate measures of isolated organizations or religious organizations, and to test how different types of religious congregations are associated with industrial pollution. To this end, Model 4 includes the same covariates as Model 2 and Model 3, but replaces the composite religious congregations measure for three separate measures of the density of Evangelical, Mainline Protestant, and Catholic organizations.

Findings from Model 4 illustrate the utility of this approach in that the associations vary by the type of religious organization. Specifically, the main effect for Evangelical congregations is both positive and statistically significant, but it is not statistically significant for Mainline Protestants or Catholics, although both coefficients are positive. Tracts are exposed to greater health risks from industrially produced toxic air in metropolitan areas with a greater density of Evangelical congregations, but not in ones with more Catholic congregations or Mainline Protestant congregations.

Metropolitan controls in Model 4 and Model 5 indicate important distinguishing factors that are associated with disparities across urban areas. Urban areas in the West, compared to the East, are associated with a lower toxic concentration for tracts in those

Table 3.2. Religious Organizations: Regression Results for Multilevel Analysis of Block Group-level Toxic Concentration in Metropolitan U.S.

	Model 1	Model 2	Model 3	Model 4	Model 5
Block Group Level					
Prop. Minority	1.24 ***	1.24 ***	1.27 ***	1.24 ***	0.83 ***
	(0.03)	(0.03)	(0.03)	(0.03)	(0.11)
Prop. Owner-Occupied	-1.42 ***	-1.42 ***	-1.42 ***	-1.42 ***	-1.45 ***
	(0.03)	(0.03)	(0.03)	(0.01)	(0.03)
Median Income (in thousands)	0.02 ***	0.02 ***	0.02 ***	0.02 ***	0.02 ***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Median Income, Squared (in thousands)	-0.5e-4 ***	-0.5e-4 ***	0.6e-4 ***	-0.5e-4 ***	-0.5e-4 ***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Prop. Manufacturing Workers	1.97 ***	1.97 ***	1.98 ***	1.97 ***	1.91 ***
	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)
Population	-0.2e-4 ***	-0.2e-4 ***	-0.2e-4 ***	-0.2e-4 ***	-0.2e-4 ***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Metropolitan Level					
Census Region (East ref.)					
South		-0.76	-0.76	-0.92 +	-0.92 +
		(0.46)	(0.46)	(0.57)	(0.56)
Midwestern		0.59	0.59	0.52	0.52
		(0.43)	(0.43)	(0.45)	(0.45)
West		-1.15 *	-1.15 *	-1.3 *	-1.3 *
		(0.45)	(0.45)	(0.54)	(0.54)
Median Income (in thousands)		-0.02	-0.02	-0.02	-0.02
		(0.02)	(0.02)	(0.02)	(0.02)
Prop. Black or Hispanic		-1.56	-1.56	-1.61 +	-1.61 +
		(0.95)	(0.95)	(0.96)	(0.96)
Residential Segregation		0.93	0.93	0.89	0.89
		(0.81)	(0.81)	(0.82)	(0.82)
Population (Logged)		0.79 ***	0.79 ***	0.79 ***	0.79 ***
		(0.18)	(0.18)	(0.18)	(0.18)
Total Congregational Density		0.21 ***	0.21 ***		
		(0.04)	(0.04)		
Evangelical Density				0.22 ***	0.22 ***

Evangelical Density				0.22 ***	0.22 ***
				(0.06)	(0.06)
Mainline Protestant Density				0.18 +	0.18 +
				(0.1)	(0.1)
Catholic Density				0.14	0.14
				(0.29)	(0.29)
Cross-Level Interactions					
Total Congregational Density x Prop. Minority			0.04 ***		
			(0.01)		
Evangelical Density x Prop. Minority					0.08 ***
					(0.01)
Mainline Protestant Density x Prop. Minority					-0.12 ***
					(0.03)
Catholic Density x Prop. Minority					-0.3 ***
					(0.08)
Level-1 *N*	363	363	363	363	363
Level-1 Variance	6.95	5.22	5.22	5.22	5.22
Level-2 *N*	58,781	58,781	58,781	58,781	58,781
Level-2 Variance	1.57	1.57	1.57	1.57	1.57
Intra-Class Correlation Coefficient	0.82	0.77	0.77	0.77	0.77

regions, and more populous metropolitan areas are associated with more toxic air.[5]

Model 5 includes the results for three cross-level interactions between each religious congregation density measure and the tract-level racial composition variable. While in Model 3 the total number of congregations was associated with extended racial inequalities, only the interaction for density of Evangelical congregations is positively associated with exposure to toxic air. By contrast, the interactions for density of Mainline Protestant congregations and Catholic congregations with the racial composition measure are negative and statistically significant. This means that racial inequalities are accentuated in metropolitan areas with more Evangelical churches but attenuated in urban areas with more Mainline Protestant and Catholic congregations.

Figure 3.1 showcases the effect sizes for these interactions. Each line in the graph corresponds to a type of religious organization at one of two levels of racial composition: ten percent more black or Hispanic residents than group (metropolitan) mean, and ten

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[5] A supplemental model tested for interactions between the census regions and each of the religious organization measures. This model includes the same covariates and interactions as Model 5 in Table 3.2. The primary findings in Model 5 about religious congregations and each of the interactions with tract racial composition are similar in this supplemental model. There are additional differences by region. With the reference category as the East, the interaction between the West and each type of religious congregation is statistically significant; it is negative for Catholics and Evangelicals, and positive for Mainline Protestants. The interaction is also statistically significant for the South and Catholic congregations, and the interaction is positive. All other interactions are not statistically significant. These findings suggest that there is mixed evidence for region-specific findings for any linkages between religious congregations and industrial air pollution. Notably, the findings show that the findings might vary in particular in the West.

percent less than the group mean. With the x-axis denoting the density of a given religious organization at percentiles ranging from the 5^{th} to 95^{th} percentile, the interactions showcase three primary findings. First, racial inequalities are found for each type of religious organization; the lines denoting the tracts with ten percent greater black and Hispanic residents are higher compared to the lines ten percent below for each religious congregational type. Second, there are metropolitan disparities by type of religious organization. The statistically significant findings for Evangelical congregations are found in these models in the steeper increases for these congregations, while the increases for Catholic and Mainline Protestant congregations are more modest given that the associations were previously found to not be statistically significant. The increases evinced for Evangelical organizations are clearly the largest effect size among the variables considered here. Third, the interactions show that for the gap between the two lines (and therefore between different racial compositions at the tract level) accentuates as the number of Evangelical organizations increases. By contrast, the gaps for the other two types of congregations are slightly smaller as the number of organizations increases.

Taken together, the findings in Model 4 and Model 5 and in Figure 3.1 partly rebut the findings in Model 2 and Model 3 that show that religious organizations are associated with industrial pollution in a way that suggests they are isolated organizations. The findings here showcase that different types of religious organizations are not patterned in the same ways as they relate to industrial pollution. The density of Evangelical congregations is associated with increased industrial air pollution, especially for tracts with more black and Hispanic residents. not Catholics and Mainline Protestants do not have a statistically significant main effect, but are both are associated with smaller racial inequalities in exposure to industrial pollution. In total, these results show that each type of religious organization is not associated with industrial pollution in the same way.

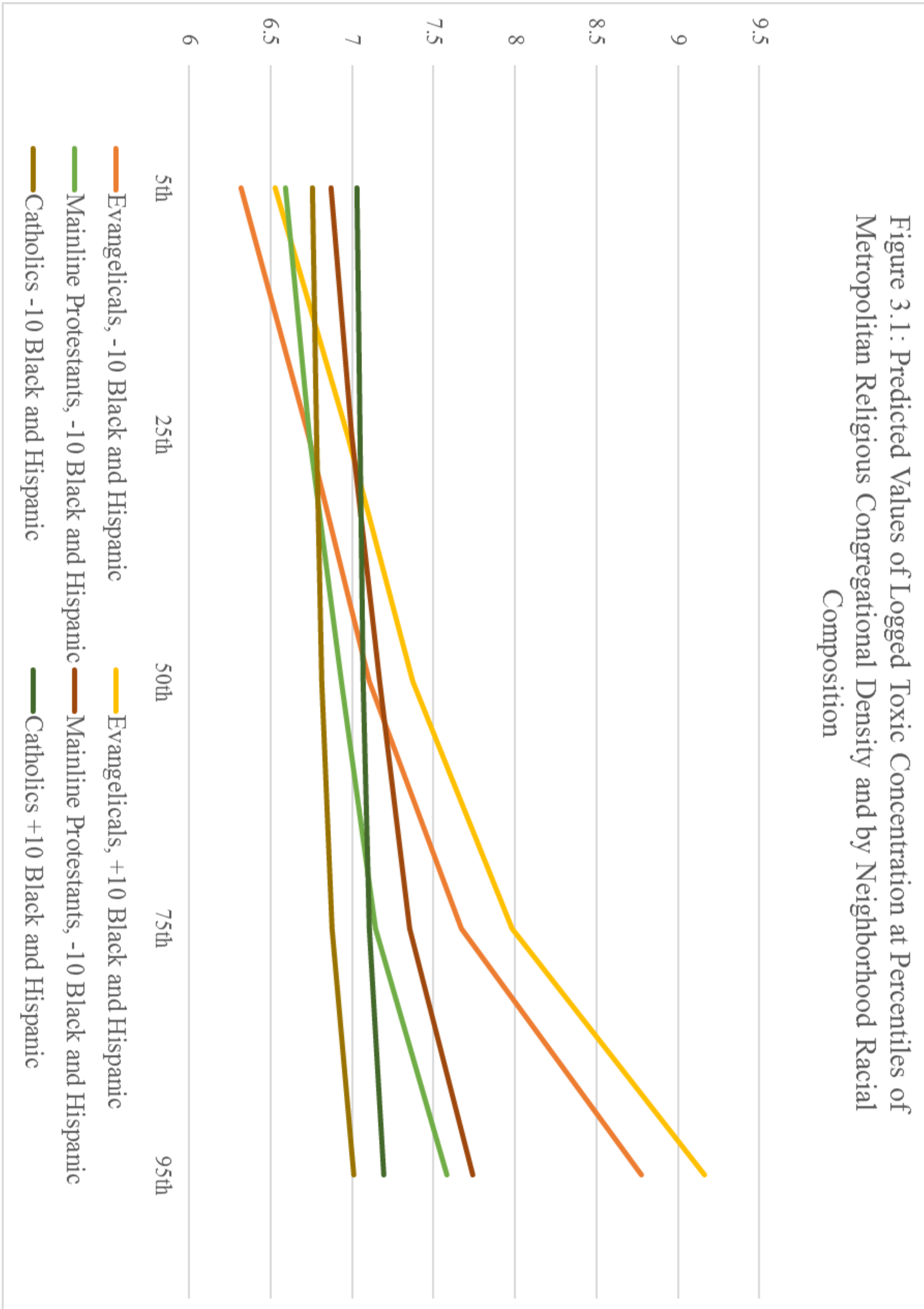


Figure 3.1: Predicted Values of Logged Toxic Concentration at Percentiles of Metropolitan Religious Congregational Density and by Neighborhood Racial Composition

Finally, supplemental models replicate Models 2 through 5 in Table 3.2 but instead use measures of religious adherents instead of religious organizations. These models can be found in Table 3.3. Findings are largely similar to those in Table 3.2, with two important exceptions. As was the case with religious organizations, the number of religious adherents is associated with greater industrial pollution, but a difference is found in that the coefficient for the interaction is now negative and statistically significant; it was positive in the organizations model. This change is primarily due to the fact that the overall organization measure is comprised of primarily Evangelicals, but the plurality of adherents (49 percent) are Catholics. In this way, it follows theorized relationships in that the organizational measure is more closely associated with bonding ties (and the interaction is positive), but the adherents measure is more closely associated with bridging ties (and the interaction is negative).

The main effect for Evangelical adherents are associated with more toxic air in a metropolitan area, but the interaction is not statistically significant, a difference from Model 5 in Table 3.2. One reason for the difference for the interaction may be that the number of organizations is particularly meaningful in that it not only promotes bonding ties, but further fractures the overall civic milieu with a highly decentralized organizational network. Main effects for Mainline Protestants and Catholics are not statistically significant, mirroring the organizational findings. The findings are also paralleled for both the interaction for Mainline Protestant adherents and Catholic adherents, which are negative and statistically significant. Figure 3.2 showcases the interaction findings for the adherent measures in the same manner as Figure 3.1. In this figure, the distinctions across different percentiles of Mainline Protestants and Catholics

Table 3.3. Religious Adherents: Regression Results for Multilevel Analysis of Block Group-level Toxic Concentration in Metropolitan U.S.

	Model 1		Model 2		Model 3		Model 4	
Block Group Level								
Prop. Black or Hispanic	1.24	***	1.27	***	1.24	***	1.3	***
	(0.03)		(0.03)		(0.03)		(0.03)	
Prop. Owner-Occupied	-1.42	***	-1.42	***	-1.42	***	-1.44	***
	(0.03)		(0.03)		(0.03)		(0.03)	
Median Income (in thousands)	0.02	***	0.02	***	0.02	***	0.02	***
	(0.00)		(0.00)		(0.00)		(0.00)	
Median Income, Squared (in thousands)	-0.5e-4	***	-0.5e-4	***	0.5e-4	***	-0.6e-4	***
	(0.00)		(0.00)		(0.00)		(0.00)	
Prop. Manufacturing Workers	1.97	***	1.99	***	1.97	***	1.99	***
	(0.1)		(0.1)		(0.1)		(0.1)	
Population	-0.2e-4	***	-0.2e-4	***	-0.2e-4	***	-0.2e-4	***
	(0.00)		(0.00)		(0.00)		(0.00)	
Metropolitan Level								
Census Region (East ref.)								
South	-0.14		-0.14		-1.6	**	-1.6	**
	(0.45)		(0.45)		(0.58)		(0.58)	
Midwestern	0.65		0.65		0.07		0.07	
	(0.44)		(0.44)		(0.45)		(0.45)	
West	-1.05	*	-1.05	*	-1.78	**	-1.78	**
	(0.48)		(0.45)		(0.53)		(0.53)	
Median Income (in thousands)	-0.06	**	-0.06	**	-0.04	*	-0.04	*
	(0.02)		(0.02)		(0.02)		(0.02)	
Prop. Black or Hispanic	-3.47	***	-3.47	***	-1.95	+	-1.95	+
	(0.93)		(0.93)		(1.02)		(1.02)	
Residential Segregation	1.07		1.07		0.54		0.54	
	(0.83)		(0.83)		(0.82)		(0.82)	
Population (logged)	0.65	***	0.65	***	0.72	***	0.72	***
	(0.18)		(0.18)		(0.18)		(0.18)	
Total Adherent Density	3.37	**	3.37	***				
	(1.16)		(1.16)					
Evangelical Density					6.7	***	6.7	***
					(1.46)		(1.46)	

Mainline Protestant Density			3.5	3.5
			(3.25)	(3.25)
Catholic Density			0.01	0.01
			(1.43)	(1.43)
Cross-Level Interactions				
Total Adherent Density x Prop. Minority		-2.41 ***		
		(0.27)		
Evangelical Density x Prop. Minority				-0.61 +
				(0.32)
Mainline Protestant Density x Prop. Minority				-3.43 ***
				(0.68)
Catholic Density x. Prop. Minority				-3.54 ***
				(0.29)
Level-1 *N*	363	363	363	363
Level-1 Variance	5.44	5.44	5.21	5.21
Level-2 *N*	58,781	58,781	58,781	58,781
Level-2 Variance	1.57	1.57	1.57	1.56
Intra-Class Correlation Coefficient	0.78	0.78	0.77	0.77

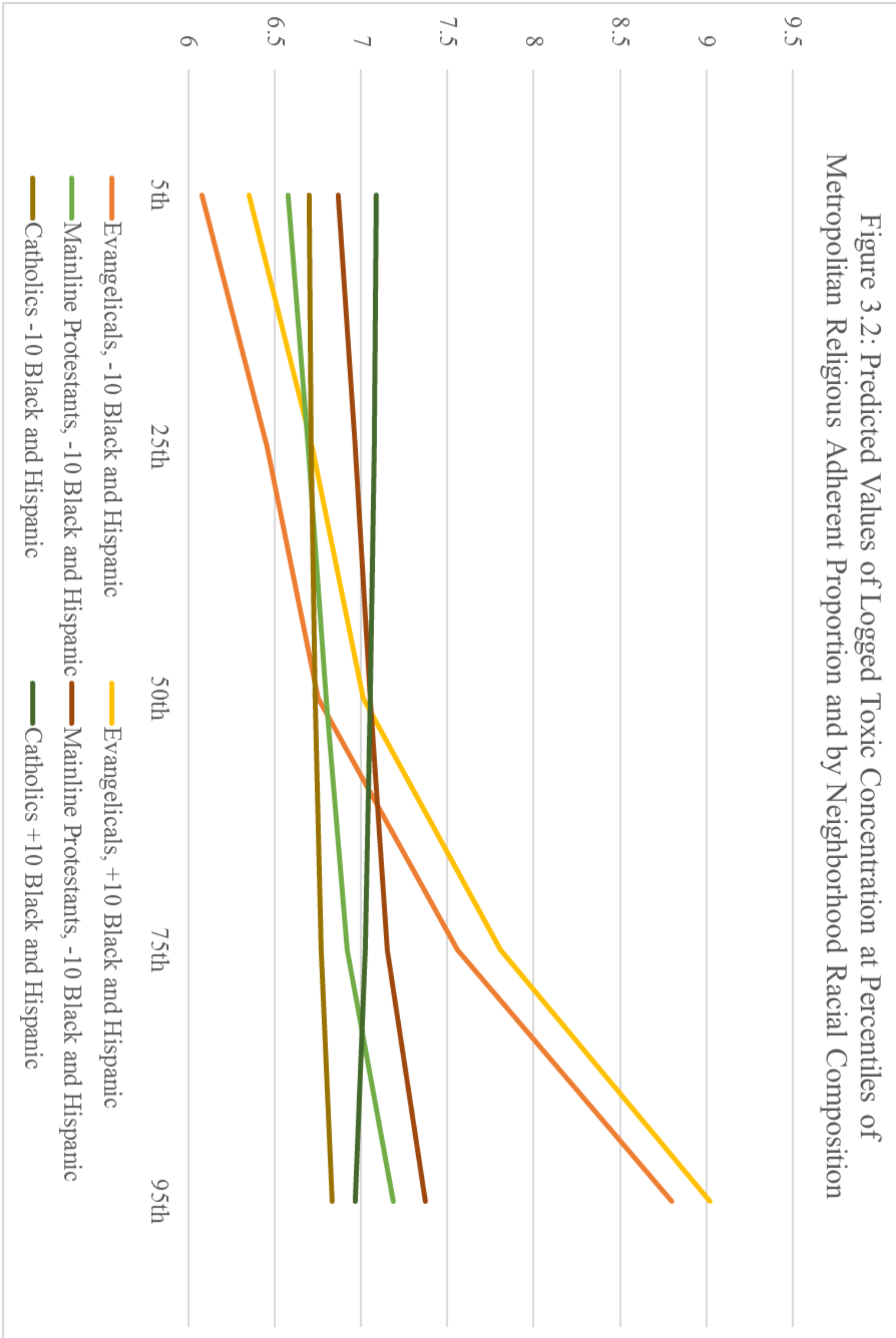


Figure 3.2: Predicted Values of Logged Toxic Concentration at Percentiles of Metropolitan Religious Adherent Proportion and by Neighborhood Racial Composition

by different levels of racial composition in the tract showcase how the gaps attenuate somewhat as the amount of adherents increases. In summary, the two changes concern

(1) the interaction between the overall proportion of adherents and race, and (2) the interaction between Evangelical adherents and tract-level racial composition.

3.5. Discussion and Conclusion

Previous approaches to the study of metropolitan disparities and environmental racial inequalities has not accounted for why or how these differences have emerged. Emphases on spatial inequality (such as with residential segregation) or with material inequalities (such for income by race) have yielded, at best, mixed findings (Ard 2016; Ash et al. 2013; Downey 2007; Downey et al. 2008; Morello-Frosch and Jesdale 2006). By investigating measures relating to social capital and civic capacity, this research sought to move to a new field of analysis to better elucidate the processes that contribute to inequalities in industrial pollution.

The results support hypotheses related to civic capacity and social capital. Additionally, the findings presented in this paper suggest that civic capacity through social capital organizations operates differently depending on the type of organization under examination. One primary finding is that the density of a cumulative measure of Evangelical, Mainline Protestant, and Catholic congregations as well as a measure of adherents is positively associated with industrial pollution. This suggests that the aggregate effect webs of ties and organizational resources in religious organizations in the United States is linked to greater environmental problems.

Decomposing these measures, however, yields differential findings depending on the religious congregation being studied. Evangelical congregations are associated with higher levels of industrial pollution for all neighborhoods within metropolitan areas with more Evangelical organizations as well as larger racial inequalities in exposure to toxic air, although the latter finding does not hold when using a measure of adherents instead of organizations. The finding for Evangelical organizations suggests that the diffusion of free market ideologies and greater insularity of social ties that are found with these organizations links with a collective disinterest in deterring pollution and the encouragement of economically productive industrial polluters. The conflicting findings for congregations and adherents for Evangelicals only partly supports hypotheses about how racial inequalities are extended in places with more Evangelicals (Blanchard et al. 2008; Emerson and Smith 2000; Lee 2010; Tranby and Hartmann 2008). It could be the case that the organizational measure is correlated with inequalities and the measure of adherents is not associated because these organizations are primary centers of resources and social infrastructure. It may not be the total number of ties that matter in this particular case, per se, but rather that the organizational impetus is decentralized to the point that it inhibits efforts at lessening inequality.

Catholic congregations and Mainline Protestant congregations (as well as both group's levels of adherents) are associated with smaller racial inequalities in metropolitan areas with more of these congregations, and the main effect of each of these measures is not associated with industrial pollution. These findings show that urban areas with a stronger collective potential composed of more bridging ties are not linked to overall levels of pollution. At the same time, though, greater number of these ties through organizations and adherents are correlated with smaller inequalities. In this way, the findings suggest that the bridging character of Catholics and Mainline Protestants links to environmental inequalities, which are related to wider social inequalities in housing and income (and beyond), but not to the more specific environmental problem of industrial pollutants and the more general issue of manufacturing prowess.

In all, these findings suggest that not only is social capital and civic capacity linked to industrial pollution, but also that it depends on the amount and type of social capital across different religious organizations. These findings mostly, but not totally, pair with assumptions about the bonding and bridging properties of religious organizations, and with theory about the defense of place (Rudel 2013). Evangelical congregations match theorized assumptions, namely that more of these congregations in a place are associated with worse social outcomes and greater inequalities because these organizations are characterized by a relatively high amount of bonding social ties. Although opposite the findings for Evangelical congregations, findings for Catholic congregations and Mainline Protestants also mostly pair with assumptions in that greater numbers of these congregations do not worsen overall levels of metropolitan industrial pollution and are associated with smaller racial inequalities. Across these three types of organizations, the import of bonding and bridging social ties suggests that not only is social capital associated with industrial pollution, but that distinct conceptualizations of social capital are warranted to analyze environmental inequality.

These findings have theoretical implications for the study of environmental inequality. Thematically, it suggests that an orientation toward the foundational social character of a place can be useful alongside the study of more direct contestation of environmental degradation. This social characterization of place is evinced through amount and types of social capital ties through religious organizations. Findings about bridging social ties mostly suggest that a greater number of organizations that typically host such ties are associated with attenuated racial inequalities. This showcases how these cross-cutting relationships in a place may underwrite a sociopolitical milieu that does not inculcate high levels of inequalities, including environmentally. The findings about bonding social ties in a metropolitan area indicate that places with greater number of these organizations with isolating ties are associated with more pollution, and extended inequalities. The cumulative nature of these ties in an area as large as a metropolitan area might suggest that these ties are used for bonding processes that inhibit larger conversations and actions to address systemic metropolitan inequalities and heightened levels of environmental degradation.

These findings together aver that the way in which residents of a metropolitan area come together can encourage or discourage patterns of action, therein providing a backdrop to the production of socioenvironmental contexts. It suggests that there are two ideal typical kinds of cities, in terms of their social capital, that correspond and extend what Blanchard calls “closed communities” and what Tolbert (2004) calls strong “civic communities.” At one end of a spectrum, closed communities would have more bonding organizations, and a lower number of bridging organizations. At the other end, strong civic communities would have more bridging associations but fewer bonding associations. The civic capacity underwritten by being in type of city or the other is linked to a place’s engagement with social justice issues broadly.

This study has limitations which promote possibilities for future research. First, this study has primarily focused on industrial air pollution, but leaves aside discussion of other pollutants such as those from transportation or household sources as well as land-based pollution and water pollution. Second, a study of social capital organizations and industrial pollution could be extended to other types of social capital organizations, such as environmental associations or elite civic organizations, as well as an examination of organizational dynamics with richer data on the characteristics of organizations. While this study took advantage of the rich data in the Religious Congregations and Membership Study, other data sets on social capital organizations should be employed to further analyze findings presented here. Third, this study has not accounted for industrial pollution from medium and small facilities that may also emit potentially large amounts of dangerous emissions (Elliott and Frickel 2015).

Religious organizations are a primary conduit of social capital in the United States. Industrial pollution is long acknowledged to be the product of contestations and civic character that shape the levels of pollution in an urban area as well as the extent of racial inequalities (Bullard 1990; Pellow 2002). How religious organizations, then, are linked to industrial pollution is a critical site of social science research. As the present article shows, different types of religious organizations are associated with health risks and racial inequalities in rather different ways. This speaks to the importance of considering how we come together and what the implications are for the air we breathe.

CHAPTER FOUR: MANUFACTURING HISTORY AND INDUSTRIAL POLLUTION IN THE UNITED STATES

Since the rise of heavy manufacturing in the nineteenth-century, industrial capitalism and pollution have been deeply intertwined (Foster, York, and Clark 2010). At that time, Friedrich Engels described the horrors of intensive pollution and its impact on England's working classes (Engels 1844). Lightly regulated industries of the early and mid-twentieth centuries left the scars of both highly toxic Superfund sites as well as unknown other pollutants in their wake (Elliott and Frickel 2015; Hurley 1995). Today, research demonstrates still a close link between the size of an area's manufacturing population and the amount of industrial pollution in that area (Elliott and Smiley forth.; Sicotte and Swanson 2007; Taylor 2014).

Even as industrial outputs remain ever essential in a capitalist-driven consumer economy, the economic game – at least in the United States – has changed. The past fifty years have witnessed a long decline of manufacturing work in the United States. In 1970, nearly one in four American workers were employed in manufacturing, but in 2015 just eight percent of U.S. residents were manufacturing workers. This fundamental restructuring of the economy has had massive implications for the quality and quantity of blue collar work, as well as far-reaching effects across the globe as some industries decamp for countries with less expensive workforces. In its place, the United States has shifted to a postindustrial economy, one characterized by increased attention to white collar professionals and a ballooning of unstable service economy work. This well-known narrative about the decline of industrial economy in the United States is one that has been of great sociological interest across many fields, whether it is the changing face of work in the United States (Bell 1973; Hatton 2011), how cities are powerfully changed by these trends (Harvey 2013; Zukin 1991), or the unequal ecological exchange between developed and developing countries (Foster, York, and Clark 2010; Jorgenson 2016), among others.

Research on environmental inequality in the environmental justice tradition has long analyzed exposure to industrial pollution (e.g. Bullard 1990; Mohai, Pellow and Timmons 2009; Taylor 2014), but it has not supplied a measurable sense of how this changing industrial economy has influenced unequal pollution exposure in the United States. Instead, the link between manufacturing work and industrial pollution exposure is typically assumed to have had the same relationship, whether it is 1980 or 2017: more manufacturing workers in a place are linked with greater toxins (Bullard 1990; Sicotte and Swanson 2007). This admittedly obvious link supplements research typically as a control variable that otherwise importantly centers the discussion on racial inequalities across neighborhoods (Ard 2016; Collins et al. 2016; Mohai and Saha 2015a).

But as recent research on the socioenvironmental connections between urbanization and manufacturing facilities demonstrates (Elliott and Frickel 2013; Elliott and Frickel 2015), the link between a changing economy and inequalities in toxic air deserves more than a superficial examination. In particular, the decline of manufacturing work should be examined across time, and in the context of how it is related to racial inequalities. In doing so, I link to research that foregrounds the “industrial” part of “industrial pollution” that studies organizational attributes of heavy polluting facilities (Collins et al. 2016; Grant et al. 2010), but push it further by examining how place-based historical trajectories of the economy affect social outcomes, especially environmental ones (Logan and Molotch 2007; Molotch, Freudenberg, and Paulsen 2000).

In this article, I investigate how historical and contemporary configurations of the economy are related to contemporary exposure to industrially produced toxic air. Using state-of-the-art industrial air pollution data, I examine how manufacturing employment from 1970 to 2010 in a metropolitan area as well as changes therein relate to levels of industrial pollution in 2010. Findings show that the both the historical and contemporary presence of manufacturing workers in a metropolitan area are associated with increased exposure to toxic air. Findings also show that metropolitan areas with declines in manufacturing employment are associated with higher levels of pollution. In some ways, this finding is counterintuitive: more manufacturing workers is typically associated with more pollution. But these findings indicate that contemporary pollution exposure is strongly linked to historical forms of the economy.

4.1 Literature Review

Environmental inequality in the United States disproportionately disadvantages people of color in exposure to many types of environmental degradation. One of the most important and well-documented forms of environmental degradation is industrial pollution. Most often, these studies analyze proximity to industrial facilities (Mohai and Saha 2007; Bryant and Mohai 1992), the amount of pollutants (Crowder and Downey 2010; Pais, Crowder, and Downey 2013), or, more recently, the health risks from chemical emissions (Ash et al. 2013; Ard 2016). These studies highlight the racial and class makeup of the neighborhoods, and thereby illustrate the powerful and lasting inequalities along racial lines in the United States. An additional area concerns the number of manufacturing workers in a residential area. More manufacturing workers in a neighborhood are associated with greater exposure to environmental degradation (Mohai and Saha 2015a; Sicotte and Swanson 2007), and different facility attributes (such being a branch facility) are also linked with pollution outcomes (Grant et al. 2010; Prechel and Zhang 2012).

This focus on manufacturing facilities and on the characteristics of the working population of polluted neighborhoods leaves aside important questions about the cumulative effects on the metropolitan economy. More specifically, while the economic composition relating to facilities and manufacturing is often discussed in *neighborhoods*, little, if any, attention is paid to the total of these characteristics in *cities*. This is despite the fact that industrial and environmental historians as well as qualitative environmental justice researchers have drawn attention to urban and regional trajectories of certain industries, and how that relates to pollution (Carter 2014; Hall 2012; Hurley 1995; Pellow and Park 2002; Sicotte 2016; Spears 2014). This line of research highlights how present-day pollution patterns did not occur overnight; rather, they are products of lasting industrial economies, elite actions, and governmental guidance (Pellow 2002).

How these histories came to be can be connected to the environmental sociology of Max Weber by identifying how the impacts of environmentally intensive industry constrains social action across time. Foster and Holleman (2012) summarize this thesis thusly: “Weber’s analysis of the environmental conditions of capitalism, in fact, places heavy emphasis on the energy-intensive and fossil-fuel-intensive nature of the system, which could eventually place limitations, he suggested, on its further development” (Foster and Holleman 2012:1633). The “refraction” of capitalist development and environmental degradation implicates itself through cultural logics that condition modes of the economy, and vice versa. A process of rationalization of the capitalist production of pollution is initiated. Taking these refractions of economy, environment, and culture together, they constitute an “iron cage” in which the contradictions of capitalism furnish both its continuity and constraint.

While Weber’s interest was in the larger macro-level trends in economy and history, these cultural logics and the attendant iron cage may be implicated in place-specific contexts. After all, cities are seen as the place in which the surplus capital is most often invested, and are the exemplar of capitalist development (Harvey 1973; Castells 1977). As Molotch, Freudenberg, and Paulsen (2000) detail, “lash-ups” of actions in a community (especially by elite actors in commerce and government) in past time periods structure the future possibilities for action in that place. This constitutes a place tradition in which the elements of “economy, demography, politics, organizations, culture, and aesthetics… combine and endure, and in the salience and meaning that locals and outsiders given them” (Paulsen 2004:245; see also Brown-Saracino 2015; Kaufman and Kaliner 2011; Rushing 2009; Smiley, Rushing, and Scott 2016). Molotch, Freudenberg, and Paulsen’s (2000) study analyzed two California cities – Santa Barbara and Ventura – and how their contemporary cities emerged from historical actions about economy, urban form, and environment. They examine the relationship between environmentally intensive oil and gas industries and urban history, particularly how elite actions and community organizations pushed these theoretically similar cities in different directions (Ventura toward oil and gas industries, and Santa Barbara away from them). More broadly, this place-specific perspective pairs also with Downey’s (2015) “inequality, democracy, and the environment" perspective which stresses the institutional processes and elite actors enabling environmental degradation.

The theoretical offerings of Weber and the environment (Foster and Holleman 2012) and place tradition (Molotch, Freudenberg, and Paulsen 2000) offer a possible synthesis through which metropolitan economy-environment relations can be studied. Capitalist development has long exploited urban environments with toxic air, contaminated water, and ground-based toxins. Particular industries in an urban area initiated and intensified this environmental degradation. "Rational" cultural logics emerged in support of these particular industries. A refraction process ensues, whereby industrial economy, environmental degradation, and cultural logics interact in specific places to form an iron cage. This iron cage is part and parcel of a wider place tradition that is primarily supported by economic and civic elites. Even as urban areas in recent decades shift away from industrial economies, place tradition continues to provoke only certain paths of possibility, and inhibit others. This means support of these historical industries, even as they may cut workforces in favor of automation or international relocation. This support leaves industrial pollution relatively unquestioned and under-regulated on the local level. Moreover, these processes imply that present-day pollution from industrial sources may have more to do with capitalist development set in motion decades ago.

This environmental iron cage of place tradition perspective could provide a way to investigate inequalities across urban areas in exposure to industrially produced toxins. To date, research on these metropolitan disparities have analyzed several areas of interest, but with only limited insight into processes at play (Schweitzer and Stephenson 2007).

One area of analysis concerns residential segregation, namely that places with greater residential segregation also have more pollution and accentuated racial inequalities in toxic exposure. Research suggests on this, though, suggests a mixed effect with some studies either finding weak support (Downey 2007) or support for only some measures of residential segregation but not others (Ard 2016). A second area similarly concerns racial inequality, such as racial income inequality or the percentage of minorities in a residential area. Neither of these have been found to be associated with environmental inequality (Downey 2007; Downey et al. 2008; Ard 2016). Finally, the overall levels of metropolitan pollution have been shown to be associated with attenuated racial inequalities (Ash et al. 2013). Across these studies, we have little measurable sense of why disparities in industrial pollution in metropolitan areas have emerged, and how that might be related to patterns of racial inequalities.

By contrast, though, a Weberian place tradition perspective suggests that historical economic patterns and cultural logics condition contemporary pollution patterns. No previous quantitative study of industrial pollution exposure has tested for historical economic patterns. Qualitative and historical research emphasizes both of these areas, though. In particular, investments in certain industries at one time, especially during America's industrial halcyon period in the mid-twentieth century, shape present-day pollution. In cities and regions like Houston with oil and gas industries (Feagin 1988; Melosi and Pratt 2007; Elliott and Smiley Forth.), Silicon Valley with technological toxins (Pellow and Park 2002), and in Chicago as a receiving point for resource extraction (Cronon 1991; Pellow 2002), the shape and extent of environmental inequality is both historically constructed, and continuously enabled by preexisting cultural logics.

In this way, the historical composition of the economy may be just as important to levels of industrially produced environmental degradation as the contemporary economy. This is the case because the historical economy was relatively more industrial than the today's economy, and because that industrial emphasis structures the realm of the possible in the present day. It does so by constituting an environmental iron cage, one that renders capitalist developments and attendant environmental degradation across time as rational, and endogenous to the urban area's tradition.

4.2. Data and Methods

The primary premise of this paper is to investigate how urban industrial histories intertwine with present-day pollution exposure. By analyzing the presence of manufacturing workers in metropolitan areas as well as changes in this population across recent decades, overall exposures across metropolitan areas are examined, as are patterns of racial inequalities within these areas. In doing so, the goal is to test to see if the changing industrial economy is linked to industrial air pollution, and, if so, link these changes to theoretical offerings about preexisting place traditions.

To accomplish this, I utilize multilevel models that foreground the importance of the metropolitan context in shaping local neighborhood contexts. Multilevel models are used because the present paper is particularly interested in how metropolitan-level processes condition pollution exposure at a more localized scale. Because data is drawn from multiple time points, I standardize the definition and boundaries of metropolitan areas using 2010 delineations.[6] While this decision inflates the geographic extent of 1970

[6] While tabulating the statistics for metropolitan areas across time is a straightforward task insofar as aggregating data on counties, a small number of counties in the United States changed boundaries between

metropolitan areas, for 2010 it takes into account commuting patterns across counties, which are the patterns that form the basis for the geographic boundaries of metropolitan areas. Using 1970 metropolitan boundaries, on the other hand, would not be inclusive of many 2010 workers; for example, a suburban county resident in 2010 who works in manufacturing in the central city would not be included in the totals if that county falls outside the metropolitan boundaries in 1970. By contrast, if a county is not in a metropolitan area in 1970 but it is in 2010, it stands to reason that counting the workers within the 2010 boundaries is valid because its manufacturing workers in 1970 likely would be employed within their home county. Metropolitan areas and census tracts are drawn from the contiguous United States. The number of metropolitan areas used in the analysis is 363, and the number of census tracts are 58,780.

4.2.1. Independent Measures - Metropolitan

1970 and 2010. In some cases, these boundary changes occurred within the boundaries of a metropolitan area or were in non-metropolitan areas. Three groups of changes did affect metropolitan boundaries. First, Broomfield County in Colorado was created in 2001 from parts of Adams County, Boulder County, Jefferson County, and Weld County. Boulder County comprises its own metropolitan area, Weld County is in the Greeley Metropolitan Area, and Adams, Broomfield, and Jefferson are in the Denver-Aurora-Lakewood metropolitan area. Second, Cibola County, New Mexico was created in 1981 from part of Valencia County; the former is not in the Albuquerque metropolitan area but the latter is. Third, La Paz County, Arizona was created from part of Yuma County in 1982; Yuma County comprises the Yuma Metropolitan Area while La Paz County is not in a metropolitan area. To address these changes, I created a population-based weight using a “common geographies” approach (Slez, O’Connell, and Curtis 2015) that was then utilized to apportion 1970 county data into metropolitan areas based on 2010 boundaries. Models conducted without these three metropolitan areas are substantively similar to findings in this chapter.

Independent variables are utilized from the decennial United States Census and from 2006 to 2010 American Community Survey (ACS) estimates. All 1970 data is utilized from the decennial census, as is 2010, when possible. Measures in the 1970 census were either measured for the population of the United States, or for the long-form census which was asked of a fifteen percent or five percent sample of the population. For other variables (mostly socioeconomic variables) that are no longer included in the decennial census, the ACS estimates are utilized. I use the 2006-2010 five-year pooled estimates to maximize reliability. Census tracts with employed populations that are less than 100 are not included in the analysis to minimize concerns about the validity of estimated statistics.

The primary independent variables in this chapter concern the population of manufacturing workers in a metropolitan area. Since the 1960s, manufacturing industries declined markedly, such that the share of the national population in manufacturing work is a third now (8 percent) of what it was in 1970 (24 percent). With this in mind, this study takes into account three primary independent variables. The first measure is for 1970: the percent of employed workers aged sixteen or over in manufacturing industries in a metropolitan area. Second, the same variable is calculated for 2010. These variables are used in separate models, as they are strongly correlated ($r = 0.8$; $p < 0.05$). The goal for each is to test to see if the relative proportion of manufacturing employment at the metropolitan level in both 1970 and 2010 are positively associated with tract-level toxic concentration.

The third variable related to manufacturing employment is a ratio measure that divides the total number of manufacturing jobs in 1970 by the total number of manufacturing jobs in 2010. The use of a ratio variable between the number employed in manufacturing occupations in 1970 and 2010 is preferred to other alternatives such as (a) the ratio between the *proportion* employed in manufacturing industries, and (b) the difference between the number employed in manufacturing industries (i.e. subtract the two statistics). For the ratio of the proportion in each year, large differences in population change across metropolitan areas (as seen in the descriptive results below) would be masked when using the proportions. For example, a metropolitan area could maintain the same proportion of manufacturing workers even if the actual number of jobs decreases precipitously so long as the population also declined at the same rate. In this way, using the number employed in manufacturing industries corresponds to the vitality of growth in that metropolitan area *relative* to not only its previous history (i.e. 1970), but also other metropolitan areas. Still, results are shown for the ratio between proportion manufacturing in an additional section in the results and in Table 4.4.

A ratio is also preferable to a simple difference between the years because the difference does not take into account the relative size of the metropolitan area. This biases the measure toward larger metropolitan areas. For example, a metropolitan area with 500,000 manufacturing workers in 1970, and 400,000 workers in 2010 would have a ratio of 1.25. The same ratio would be found for a metropolitan area with 50,000 manufacturing workers in 1970, and 40,000 in 2010. But using a variable for the difference would give the larger metropolitan area a value of 100,000, and the smaller area 10,000, therein conceptualizing the change in the former metropolitan area at a magnitude of ten times that of the latter urban area. But the argument here is more interested in how the change would affect a particular metropolitan area: it might be theorized that the drop evinced in these examples would be felt similarly in the two areas or, at least, would not be perceived as ten times worse in the larger city. Instead, a more effective way to account for size differences such as these are inherent in the modeling procedure: more populous metropolitan areas have more census tracts. Still, it should be noted that results using the difference instead of a ratio differ from other main findings presented here.[7]

Additional primary independent variables concern population size and population change. The reason for these additional variables utilizes a similar logic as those for manufacturing. It may be the case that urban areas with tepid population growth or even population decline also have pollution patterns more closely premised on their historical urban composition than their present one. Across studies, larger cities are associated with more industrial pollution (e.g. Ard 2016). Not only may city size in 1970 matter, population decline may matter as well because cities with these declines may be experiencing urban threat in the competition for commercial growth (Logan and Molotch 2007). Growth machine interests, composed of economic and political elites, in metropolitan areas with decreased size may have been less decisive in pivoting the

[7] In a supplemental model not shown here, utilizing the difference variable instead of a ratio variable has different results from the main findings found in the chapter. Chiefly, the difference is not statistically significant, although it is positively associated with the dependent variable. The interaction effects between the difference and the tract-level racial composition variables are similar to those in Model 4 of Table 4.3 in that they are both statistically significant and negatively associated with exposure to pollution. That the measure of difference is not a statistically significant main effect (but, as is shown below, the ratio measure is) indicates that the relationships here are not a function of larger metropolitan areas losing manufacturing jobs but, rather, that the phenomenon is evinced across a wider range of metropolitans both large and small.

metropolitan economy toward postindustrial avenues. In doing so, they may have been protective of any manufacturing industries that remain, including heavy polluting ones. Therefore, I utilize three variables in separate models in the analysis: the 1970 population, the 2010 population, and a ratio between the two. The population figures in 1970 and 2010 are logged to account for rightward skew; these logged variables are not used for the computed ratio. Finally, these variables are somewhat correlated with their respective manufacturing variables, and are utilized in supplemental models that do not include the manufacturing variable.

Additional metropolitan covariates include four other measures. Table 4.1 includes the mean, standard deviation, maximum, minimum, and description for all of the variables in the study. Residential segregation is seen as a potentially pivotal predictor of inequalities whereby more residentially segregated places may have also exacerbated racial environmental inequalities and overall higher levels of industrial pollution. Ard (2016) notes that spatial measures of residential segregation are more closely linked to industrial pollution outcomes than are other measures like the popular dissimilarity index. Therefore, I computed a Global Moran's I of the proportion black or Hispanic in census tracts for each metropolitan area. A Global Moran's I statistic ranges from -1 to 1, with values toward -1 denoting dispersion, values close to 0 denoting randomness, and values closer to 1 denoting clustering. Therefore, the statistic measures if there is spatial housing segregation by race, and, if so, the relative degree of such segregation. To calculate the statistic, I use a queen-one contiguity matrix that utilizes information about the racial composition of tracts that are adjacent to a given tract. Second, the median income of the metropolitan area is included as a test to see if more affluent cities are associated with greater or less industrial pollution (Ash et al. 2013). The census region – East, South, Midwest, and West – in which the metropolitan area is located are used as dummy variables, with the South, often perceived as the most polluted region in the United States (Bullard 1990), as the reference category. All metropolitan-level independent variables (except the dummy variables for the census region) are grand mean centered.

4.2.2. Independent Measures - Tract

Census tract level variables test core environmental justice hypotheses, add integral control measures, and provide for a relatively small geographic unit with which to estimate air pollution toxins. First, I measure the racial composition utilizing the proportion black and the proportion Hispanic. These variables not only test important arguments about racial inequality in exposure to environmental degradation, but using two separate measures – one for the proportion of non-Hispanic black residents and one for the proportion of Hispanic residents – also tests for differences that some studies have evinced for different racial groups being the most disadvantaged depending on the city under examination (e.g. Downey 2007). Second, I investigate class differences by using the median income of the census tract, as well as its square. Previous research has found a curvilinear effect for median income such that working-class neighborhoods are often the most disadvantaged (Downey and Hawkins 2008). Third, the proportion of owner-occupied homes measures both the relative wealth of the tract (as home ownership is a major source of wealth in the United States), but also defense of place, as homeowners may be more inclined to invest in place-based efforts more than renters (Rudel 2013). Although the chief concern with manufacturing is to test metropolitan-level compositions

Table 4.1. Coding, mean, and standard deviation of study variables.

Variable	Coding	Mean	SD
Block Group Level			
Toxic Concentration	0 to 30,600,000 (pounds of pollutants indexed to toxicity of chemicals)	8,821.29	140,048.5
Toxic Concentration, Logged	-17.47 to 17.24 (pounds of pollutants indexed to toxicity of chemicals)	6.89	2.48
Prop. Black	0 to 1	0.23	0.15
Prop. Hispanic	0 to 0.99	0.17	0.22
Median Household Income	$2,499 to $250,0001	$58,446.43	28,481.29
Median Household Income (squared)	6,245,001 to 6.25e+10	4.23+e09	4.74e+09
Prop. Manufacturing Workers	0 to 0.66	0.1	0.07
Prop. Owner-Occupied Homes	0 to 1	0.63	0.23
Population	105 to 37,452	4,358.96	1,989.68
Metropolitan Level			
Census Region			
East	12.4% of tracts		
South	39.67% of tracts		
Midwest	25.9% of tracts		
West	22.03% of tracts		
Residential Segregation	-0.15 to 0.89 (Global Moran's I)	0.52	0.21
Median Income	$31,264 to $86,286	$48,826.69	$8,199.67
Prop. Manufacturing 1970	0.03 to 0.56 (proportion of employed civilian population aged 16 and older in manufacturing industries	0.23	0.12
Prop. Manufacturing 2010	0.03 to 0.39 (proportion of employed civilian population aged 16 and older in manufacturing industries	0.12	0.06
Manufacturing Ratio, 1970/2010	0.06 to 3.74 (number of manufacturing workers in 1970 divided by number of manufacturing workers in 2010)	1.05	0.64
Population, logged 1970	8.4 to 16.65	12.16	1.1
Population, logged 2010	10.92 to 16.75	12.68	1.06
Population Ratio, 1970/2010	0.05 to 1.33 (population in 1970 divided by population in 2010)	0.65	0.25

Sources: 1970 Census; 2010 Census; 2006-2010 American Community Survey, 2010 Risk-Screening Environmental Indicators Geographic Microdata.
Population: 58,780 census tracts. 363 Metropolitan Areas.
Note: Tract-level variables are group-mean centered, and metropolitan-level variables are grand mean centered, but are shown in this table before those transformations.

of the economy, the proportion of manufacturing at the tract level is also used as a control variable to test to see if the metropolitan manufacturing measure is associated with toxic air, net of this more local factor. Further, even though previous research suggests that few workers actually work in the tract in which they reside (Elliott and Smiley forth.), the measure usefully serves as a proxy for industrial activity in the area, which is often linked to more toxic air (Sicotte and Swanson 2007). Finally, the tract population tests to see if larger or smaller tracts are correlated with greater health risks from industrial pollution. All independent variables at the census tract level are group mean centered.

4.2.3. Dependent Variable

The primary dependent variable in this study is a neighborhood's toxic concentration. The data for the dependent variable are from the Risk-Screening Environmental Indicators Geographic Microdata (RSEI-GM). The year for the analysis is 2010, and this paper utilizes the geographically aggregated data for RSEI Version 2.3.4 (Environmental Protection Agency 2015). Using Toxic Release Inventory (TRI) data from the Environmental Protection Agency, the RSEI-GM integrates information about toxicity of chemicals, amount of emissions, and plume modeling to estimate the health risks for a given geographic area. Large industrial facilities are regulated through the TRI (and therefore are used in the RSEI-GM) if they employ at least ten full-time employees, are in specific industry sectors like mining and manufacturing, and manufacture 25,000 pounds or greater of at least one of more than 400 chemicals measured by the TRI.

Plume modeling techniques are used in the RSEI-GM to measure the fate of the release of a given chemical. Each facility in the TRI database is centered in an 810 m^2 grid cell as part of a large grid numbering more than 11 million grid cells across the United States. Each grid cell that is within a 49 kilometer radius of the facility receives a health risk value based on the estimated pounds of releases for that grid cell. Grid cells that are closer to the facility will likely receive higher toxic concentration values, and those that are further away often have lower values. These differences emerge because of the decay of chemicals across space.

To move the dependent variable to the tract level, the toxic concentration values from the grid cells must be proportionally aggregated to this higher unit (See Ard [2015] for a detailed discussion of this approach). Because the toxic concentration value for a grid cell is valid for any point within that grid cell, the tract-level toxic concentration is created by determining the proportion of the tract's area that overlaps with a grid cell, and then aggregating it accordingly. For instance, in a tract that contains four grid cells with toxic concentration values of 50, 100, 200, and 500, and the grid cells comprise 50 percent, 20 percent, 20 percent, and 10 percent of the area, respectively, the toxic concentration would be calculated:

Tract Toxic Concentration = 185 =

((50*0.5)+(100*0.2)+(200*0.2)+(1000*0.1)

The tract toxic concentration estimate is 185 in this example. This variable is highly skewed, and is log transformed to account for this rightward skew.

The RSEI-GM is a major advance in modeling of air pollution that only used a unit coincidence model (i.e. a count measure of facilities in tracts; see Mohai and Saha 2015b for a review) or those that only used pounds of pollutants (Pais, Crowder, and Downey 2013). This is because it utilizes a geographic information system, and the toxicity of the chemicals for human health. The data is not without limitations. Because it uses only large facilities in the estimation of health risks, data from small and medium-sized facilities are not included in the calculations. Additionally, the RSEI-GM only accounts for industrial air pollutants. Air pollution may come from other sources such as transportation sources and from households. Other water-based or ground-based pollution are also not included. While the data is the best national data to denote health risks from chemical air pollutants, a final limitation is that the data is estimated, and is not directly observed in each census tract.

4.3. Results

4.3.1 Descriptive Analysis

Three primary differences animate the present analysis: the first concerns large differences in pollution, the second changes in manufacturing in the United States from 1970 to 2010, and the third changes in population of metropolitan areas across time. First, large differences are observed across metropolitan areas in exposure to industrial pollution. To illustrate this dynamic, I calculated the total number of tracts in a metropolitan area that would rank in the worst 25 percent nationally. Table 4.2 shows the top ten metropolitan areas in the total number of tracts that they place among the most toxic 25 percent. The Chicago metropolitan area tops the list, followed by Houston, Detroit, Pittsburgh, and Philadelphia. Sixty-six metropolitan areas have at least half of their tracts in the worst quarter of all tracts in the United States and, in six metropolitan areas, every tract ranks among America's worst.[8] By contrast, 139 metropolitan areas do not have a single tract in the most unhealthful 25 percent, and another 69 have less than five percent of their tracts ranked among the most toxic. These immense differences showcase that some metropolitan areas are to subject to relatively small amounts of toxic air from industrial facilities, but that a subset of metropolitan areas – numbering less than a hundred – experience the brunt of toxic air in the United States.

[8] These six metropolitan areas are Anniston-Oxford AL, Blacksburg-Christiansburg-Radford VA, Kokomo IN, Lebanon PA, Muncie IN, and Rockford IL.

Almost all metropolitan areas in the United States evince sharp declines in the proportion of workers in manufacturing employment since 1970. The average percent of workers in manufacturing industries in a metropolitan area in 1970 was 23.2%, and in 2010 it had fallen to 11.7 percent. Of the 363 metropolitan areas in the analysis, all but 19 had the proportion of manufacturing workers decrease from 1970 to 2010. Even with population growth in metropolitan areas nationally from 182 million in 1970 to 252 million in 2010 (a 39 percent increase), 166 metropolitan areas had lower total number of workers in manufacturing jobs in 2010 than in 1970. A total of 226 metropolitan areas (61.7 percent) did not keep pace in growth of manufacturing workers with the overall population growth in the United States. Taken together, almost all metropolitan areas experienced proportional declines in manufacturing populations in the period from 1970 to 2010, and most also evinced declines in the total number of manufacturing workers relative to national population growth across the period.

Population growth is also uneven across the time period. Only thirty-six of the metropolitan areas had population declines during the forty-year period, and thirteen of these had a 2010 population that was more than ten percent lower than the 1970 population. Among those that experienced population growth, the average metropolitan area doubled in population (103.7% more residents), but the growth ranges from rather small amounts of growth of 0.2 percent to a threefold or higher increase in thirty-four metropolitan areas. Two out of three (65.1 percent) of metropolitan areas that more than doubled in population were relatively small metropolitan areas with less than 500,000 total residents in 2010. In all, in the period from 1970 to 2010, the combination of

Table 4.2. Most Industrially Polluted Metropolitan Areas in 2010.

Rank	Metropolitan Area	Number of Tracts in Worst 25 Percent	Percent of Total Tracts in Metropolitan Area
1.	Chicago-Joliet-Naperville IL-IN-WI	1,815	82.1 percent
2.	Houston-Sugar Land-Baytown TX	914	85.6 percent
3.	Detroit-Warren-Livonia MI	609	47.1 percent
4.	Pittsburgh PA	541	76.1 percent
5.	Philadelphia-Camden-Wilmington PA-NJ-DE-MD	532	36.1 percent
6.	Cleveland-Elyria-Mentor OH	531	83.6 percent
7.	Kansas City MO-KS	493	92.5 percent
8.	Los Angeles-Long Beach-Santa Ana CA	477	16.3 percent
9.	Minneapolis-St. Paul-Bloomington MN-WI	438	56.8 percent
10.	Cincinnati-Middletown OH-KY-IN	435	86.8 percent

increasing urbanization, general population growth, and massive economic changes spurred large differences across metropolitan areas in the size of population trends.

4.2.2. Regression Analysis of Metropolitan Manufacturing Composition

Table 4.3 shows regression coefficients in four models that focus on the presence of manufacturing workers in metropolitan areas. Findings from Models 1 and 2 include the proportion of manufacturing workers in a metropolitan area in 1970 (in Model 1), and the proportion of workers in 2010 (in Model 2). Each manufacturing measure is statistically significant, and positively associated with exposure to toxic air. For metropolitan areas with more manufacturing workers in their employed population, the exposure to toxic air across the tracts within those metropolitan areas is higher. Supplemental models that test for the logged total number of manufacturing jobs instead of the proportion measure are also positively associated with toxic air exposure. Notably, these relationships are found not only for the contemporary configuration of the economy – the 2010 manufacturing measure – but also for the 1970 manufacturing workers as well. This implies that the historical basis of the workforce and economy generally is connected with polluting industries across the long arc of urban history.

Findings in Model 3 test the change variable between the total number of workers employed in manufacturing in a metropolitan area in 1970 and the number in 2010. This ratio is positively associated with exposure to industrially produced toxic air. Ratios greater than one denote metropolitan areas that had a greater number of manufacturing jobs in 1970 than in 2010, and ratios less than one are urban areas that had more manufacturing jobs in 2010 than in 1970. The positive association, then, indicates that places that with greater manufacturing job losses in the forty-year period are exposed to higher levels of toxic air. This finding may seem somewhat counterintuitive: in Models 1 and 2, more manufacturing jobs are associated with more industrial air pollution, but Model 3 shows that places with *fewer* manufacturing jobs in 2010 compared to 1970 are exposed to the most toxic air. This finding, however, partly echoes the finding in Model 1 about the 1970 manufacturing population. That is, the historical composition of the workforce is linked to more contemporary pollution exposure. In particular, a relatively strong manufacturing workforce in 1970 sets the stage for the industrial economy that follows—and the attendant externalities in the form of air pollution.

Predicted values from the regression model illustrate this link. In a metropolitan area at the 75th percentile of the manufacturing ratio measure (with approximately 39.3 percent more manufacturing jobs in 1970 than in 2010), the predicted logged toxic concentration is 6.78. This number is 1.12 units higher than the predicted toxic concentration for a metropolitan area at the 25th percentile (a metropolitan area that has nearly fifty percent more manufacturing workers in 2010 than in 1970). This large difference – a little less than half of one standard deviation of the dependent variable – showcases the importance of industrial changes across time. Moreover, the intra-class correlation coefficient indicates that the much of the variation in the dependent variable is at the contextual level—that is, between metropolitan areas (as opposed to between census tracts). The coefficient of 0.77 suggests that the variance accounted for at this metropolitan level is three times higher than the variation at the tract level. Changing

Table 4.3. Manufacturing: Regression Results for Multilevel Analysis of Tract-level Toxic Concentration in Metropolitan U.S.

	Model 1		Model 2		Model 3		Model 4	
Tract Level								
Prop. Black	1.13	***	1.13	***	1.13	***	1.3	***
	(0.03)		(0.03)		(0.03)		(0.04)	
Prop. Hispanic	1.46	***	1.46	***	1.46	***	1.44	***
	(0.04)		(0.04)		(0.04)		(0.04)	
Median Income	0.18e-4	***	0.18e-4	***	0.18e-4	***	0.2e-4	***
	(0.00)		(0.00)		(0.00)		(0.00)	
Median Income, Squared	-0.52e-10	***	0.52e-10	***	-0.52e-10	***	-0.57e-10	***
	(0.00)		(0.00)		(0.00)		(0.00)	
Prop. Manufacturing Workers	1.78	***	1.78	***	1.78	***	1.79	***
	(0.11)		(0.11)		(0.11)		(0.11)	
Prop. Owner-Occupied Homes	-1.41	***	-1.4	***	-1.41	***	-1.46	***
	(0.03)		(0.03)		(0.11)		(0.03)	
Population	-0.2e-4	***	-0.2e-4	***	-0.2e-4	***	-0.22e-4	***
	(0.00)		(0.00)		(0.00)		(0.00)	
Metropolitan Level								
Census Region (South ref.)								
East	-0.74	+	0.17		-0.99	*	-1	*
	(0.41)		(0.4)		(0.5)		(0.5)	
Midwestern	0.34		0.07		0.64	*	0.64	*
	(0.2)		(0.31)		(0.32)		(0.32)	
West	-0.63	+	-1.08	**	-1.08	**	-1.08	**
	(0.33)		(0.33)		(0.35)		(0.35)	
Residential Segregation	1.62	**	2.22	***	1.76	**	1.76	**
	(0.58)		(0.59)		(0. 63)		(0.63)	
Median Income	-0.98e-5		-0.16e-4		0.77e-5		0.76e-5	
	(0.00)		(0.00)		(0.00)		(0.00)	

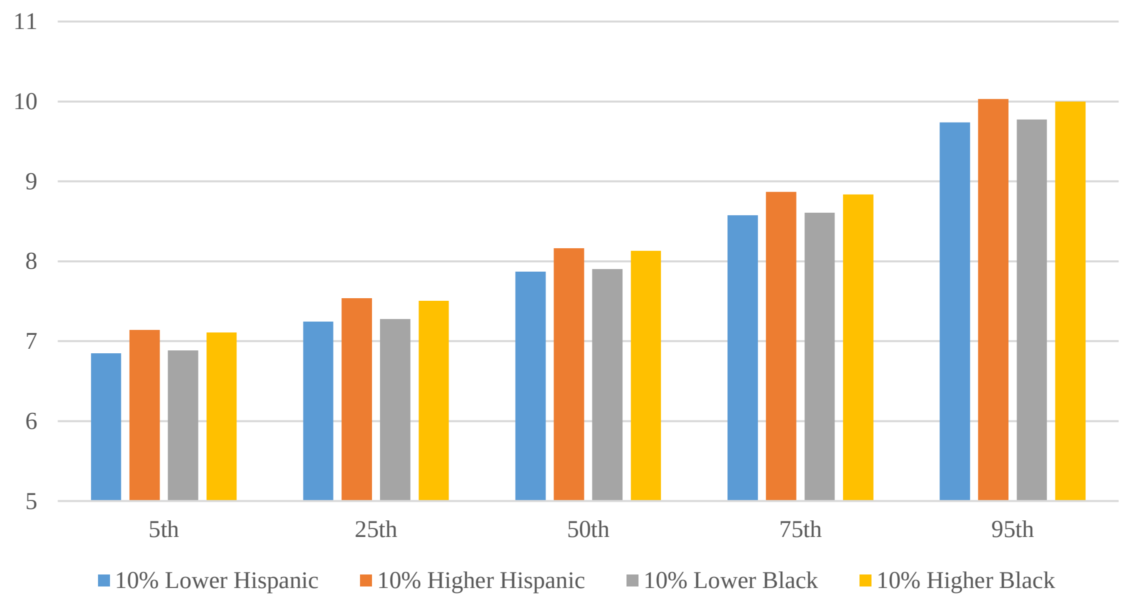
Prop. Manufacturing 1970	11.36 ***			
	(1.12)			
Prop. Manufacturing 2010		20.28 ***		
		(2.31)		
Manufacturing Change 1970 to 2010			1.36 ***	1.36 ***
			(0.25)	(0.25)
Cross-Level Interactions				
Manufacturing Change x Prop. Black				-0.57 ***
				(0.04)
Manufacturing Change x Prop. Hispanic				-0.58 ***
				(0.04)
Level-1 *N*	363	363	363	363
Level-1 Variance	4.55	4.81	5.39	5.39
Level-2 *N*	58,780	58,780	58,780	58,780
Level-2 Variance	1.57	1.57	1.57	1.56
Intra-Class Correlation Coefficient	0.74	0.75	0.77	0.78

manufacturing employment, among other metropolitan characteristics, are especially connected to contemporary environmental inequalities.

Model 4 adds two cross-level interaction terms to the covariates in Model 3. The interaction terms are between the manufacturing ratio change variable and each of the racial composition variables. The interactions are negative for both the proportion black and the proportion Hispanic, and they are also statistically significant. In metropolitan areas that have fewer manufacturing jobs in 2010 than 1970, the inequalities between neighborhoods of different racial compositions are smaller. Similar to findings suggested by Ash et al. (2013) that more polluted places have attenuated racial inequalities, these interactions show more specifically that places with manufacturing declines have a broad distribution of highly toxic air across neighborhoods across racial lines. Still, the main effects of tract-level proportion black and proportion Hispanic remain, thereby demonstrating within-city racial inequalities across this national sample.

Figure 4.1 further illustrates this relationship by examining predicted toxic concentration values at different percentiles of the manufacturing workers change ratio measure by four levels of tract-level racial composition. I use percentiles instead of standard deviations because there are no values that are two standard deviations below the mean for the manufacturing ratio. The figure showcases two important findings. First, the main effect of metropolitan stratification of industrial pollution is evident in that the bars for a given percentile are clustered at relatively similar values. In other words, there are large differences across metropolitan areas that structure tract-level inequalities, and these are conditioned by the main effect of the manufacturing change ratio. Second, racial inequalities remain robust at each level of the manufacturing change ratio, although, as the interactions indicated, the inequalities are larger in the cities with manufacturing job growth. By contrast, the more polluted cities with manufacturing workforce decline have smaller, but still evident, tract-level racial inequalities in exposure to industrially produced toxic air.

Figure 4.1: Predicted Values of Toxic Concentration by Different Percentiles of 1970 to 2010 Metropolitan Manufacturing Ratio for Different Tract Racial Composition



Metropolitan covariates in Models 1 through 4 showcase that these findings about manufacturing employment occur net of controls, but also with additional important relationships. Three findings stand out. First, residential segregation is associated with greater exposure to toxic air for tracts within a metropolitan area in Models 1 through 4. Greater racial inequalities across space extend to that metropolitan area hosting more health risks from industrial facilities. Second, the relationship for census region depends on the model under examination. None of the census regions have differences that are statistically significant in Model 1, and, in Model 2, the West is associated with lower levels of health risks compared to the South. In Models 3 and 4, the East and West regions are both associated with less industrial air pollution and the Midwest is associated with greater industrial air pollution. Third, median income of the metropolitan area is not associated with levels of industrial pollution.

Results also show that important findings at the tract level. A greater proportion of black residents and a greater proportion of Hispanic residents are associated with increased pollution, which affirms more than three decades of environmental justice research on racial inequalities in exposure to environmental degradation. The variables for median income indicate a curvilinear effect such that working-class neighborhoods are subject to the most unhealthful air compared to impoverished, middle-class, or affluent neighborhoods. Tracts with more owner-occupied homes are associated with les toxic air, as are tracts with lower populations. Higher proportion of manufacturing workers at the tract level is associated with more health risks from industrial pollution. Taken together, these findings support environmental justice hypotheses about race, class, and manufacturing employment at the neighborhood level.

Finally, it should be noted the supplemental analyses (not shown) re-tested Model 4 for a subset of metropolitan areas at certain population levels. The model's primary findings about manufacturing change held when considering only metropolitan areas with either (1) at least 1,000,000 residents, (2) at least 500,000 residents, (3) at least 250,000 residents, and (4) with fewer than 250,000 residents. The importance of testing for this is because smaller metropolitan areas may have larger jumps in the manufacturing change

Table 4.4 Supplemental Regression Results for Multilevel Analysis of Tract-level Toxic Concentration in Metropolitan U.S.

	Model 1		Model 2		Model 3		Model 4	
Tract Level								
Prop. Black	1.3	***	1.3	***	1.25	***	1.28	***
	(0.03)		(0.03)		(0.03)		(0.03)	
Prop. Hispanic	1.44	***	1.44	***	1.48	***	1.39	***
	(0.04)		(0.04)		(0.04)		(0.04)	
Median Income	0.2e-4	***	0.2e-4	***	0.2e-4	***	0.19e-4	***
	(0.00)		(0.00)		(0.00)		(0.00)	
Median Income, Squared	-0.57e-10	***	0.57e-10	***	-0.58e-10	***	-0.54e-10	***
	(0.00)		(0.00)		(0.00)		(0.00)	
Prop. Manufacturing Workers	1.79	***	1.79	***	1.8	***	1.8	***
	(0.11)		(0.11)		(0.11)		(0.11)	
Prop. Owner-Occupied Homes	-1.46	***	-1.46	***	-1.46	***	-1.45	***
	(0.03)		(0.03)		(0.11)		(0.03)	
Population	-0.23e-4	***	-0.23e-4	***	-0.2e-4	***	-0.23e-4	***
	(0.00)		(0.00)		(0.00)		(0.00)	
Metropolitan Level								
Census Region (South ref.)								
East	-0.99	*	-1.15	*	-0.34		-1.39	**
	(0.47)		(0.46)		(0.48)		(0.48)	
Midwestern	0.21		-0.38		0.86	*	-0.03	
	(0.33)		(0.34)		(0.37)		(0.35)	
West	-0.64	+	-0.82	*	-1.2	**	-1.13	**
	(0.33)		(0.33)		(0.37)		(0.34)	
Residential Segregation	1.7	**	1.93	***	2.68	**	1.98	**
	(0.62)		(0.62)		(0.68)		(0.65)	
Median Income	-0.8e-5		-0.16-5		0.35e-5		0.37e-5	
	(0.00)		(0.00)		(0.00)		(0.00)	
Prop. Manufacturing 1970	10.58	***						

	(1.33)							
Prop. Manufacturing 2010			18.97	***				
			(2.26)					
Manufacturing Change 1970 to 2010	0.24		1.17	***	0.58	**		
	(0.26)		(0.23)		(0.22)			
Manufacturing Change 1970 to 1990							3.05	***
							(0.44)	
Cross-Level Interactions								
					-0.51			
	-0.57		-0.57		(0.04)	***	-0.93	***
Manufacturing Change x Prop. Black	(0.04)	***	(0.04)	***			(0.07)	
	-0.58		-0.58	***	-0.54	***		
Manufacturing Change x Prop. Hispanic	(0.04)	***	(0.04)		(0.05)		-1.01	***
							(0.09)	
Level-1 *N*	363		363		363		363	
Level-1 Variance	4.53		4.46		5.61		5.04	
Level-2 *N*	58,780		58,780		58,780		58,780	
Level-2 Variance	1.56		1.56		1.56		1.56	
Intra-Class Correlation Coefficient	0.74		0.74		0.78		0.76	

ratio, although the range of the data is rather similar by city size.[9] The only exceptions are the findings are for the interaction terms in smaller cities (with fewer than 250,000 residents). The interaction between manufacturing change and the proportion black at the tract level is not statistically significant, and the interaction between manufacturing change and proportion Hispanic is now positive; note that the main effect remains similar for this subset of the data.

4.3.3. Supplemental Analyses of Manufacturing Change

To further analyze how changes in manufacturing employment shape the production of industrial pollution, I examine four additional models in Table 4.4. The first two models are identical to Model 4.4 in Table 4.3, but with an additional covariate: the 1970 proportion employed in manufacturing industries in Model 1, and the 2010 proportion in Model 2. These models have different, and telling, findings. In a model with the 1970 proportion of manufacturing workers, the 1970 measure is positively associated with industrial pollution (as it was in Model 1 in Table 4.3), and the manufacturing change ratio is not statistically significant. A model with the 2010 proportion is similarly associated with industrial pollution, and the manufacturing change

[9] The range of the data suggests that differences in the manufacturing ratio between larger metropolitan areas and smaller metropolitan areas are either small or nonexistent. For instance, the standard deviation for the manufacturing ratio for metropolitan areas with at least 250,000 residents is 0.67, while it is 0.61 for urban areas with more than 250,000 residents; the means are almost identical (1.06 for smaller metropolitan areas and 1.04 for larger ones). The highest values (i.e. greatest drops in manufacturing jobs) did occur in the smaller metropolitan areas, with the seven highest drops in metropolitan areas with less than 250,000 residents.

ratio remains statistically significant.[10] Together, this means that the findings for the manufacturing change ratio are robust to the inclusion of the 2010 proportion, but not the 1970 proportion. These findings support the proposition that the composition of the metropolitan economy matters in historical perspective. That the inclusion of the 1970 measure negates the statistical significance of the manufacturing ratio suggests that the 1970 manufacturing economy may be more highly linked to contemporary pollution exposure than present-day economic configurations or changes since that time.

The third supplemental model introduces a different way of calculating the manufacturing change ratio. Instead of calculating the ratio using a count of the number of manufacturing workers, I calculated it by dividing the proportion of the employed population in manufacturing industries in 1970 by the proportion in 2010. As discussed in the methods section, the primary analysis uses a ratio between the count of jobs instead of a proportion change ratio variable because of large population changes that might obscure changes in manufacturing populations, and because the number of manufacturing jobs is both an economic and cultural marker used across cities to distinguish economic vitality. Model 3 in Table 4.3 shows that the inclusion of this proportion yields similar results to those found in Model 4 in Table 4.3 in that the metropolitan manufacturing ratio is positively associated with industrial pollution exposure.[11] The effect size is smaller for

[10] Using a logged count of the total number of manufacturing jobs in 1970 and 2010 instead of the proportion in the employed population yields similar findings.

[11] Although not shown here, the inclusion of an additional covariate with the 1970 proportion in manufacturing industries or the 2010 proportion in manufacturing industries with this new manufacturing ratio variable has similar findings to those outlined about Model 1 and Model 2 in Table 4.4.

the change in proportion than it is for the change in the count, approximately half as large.

Finally, I test the change in the number of manufacturing jobs in a metropolitan area between 1970 and 1990. This period approximately corresponds to an initial and perhaps most pivotal stage in deindustrialization in the United States; moreover, it corresponds with a time period that the environmental emissions of large industrial facilities were largely unregulated by the federal government. Switching to the 1970 to 1990 change yields two intriguing findings. First, and similar to the 1970 to 2010 variable, the 1970 to 1990 change is associated with greater pollution. Drops in manufacturing across these two decades are linked to higher levels of industrial pollution in 2010. Second, an additional model (not shown) that includes the 1970 proportion in manufacturing employment showcases a difference between the finding in Model 1 of Table 4.4. Whereas the manufacturing ratio between 1970 and 2010 was no longer statistically significant with the inclusion of the 1970 manufacturing proportion in Model 1, the manufacturing ratio between 1970 and 1990 remains statistically significant. This suggests that one of the most pivotal periods of American industrial history as it relates to air pollution occurred in the years between 1970 and 1990. In a period characterized by profound deindustrialization and a lack of air pollution regulation, the loss of jobs may not have meant the loss of industry, as it set a foundation for pollution outcomes yet two decades later.

4.3.4. Supplemental Regression Analyses of Population

Table 4.5 shows regression coefficients in four models that specifically focus on population size and population change across time in metropolitan areas. These models

Table 4.5. Population: Regression Results for Multilevel Analysis of Tract-level Toxic Concentration in Metropolitan U.S.

	Model 1		Model 2		Model 3		Model 4	
Tract Level								
Prop. Black	1.13	***	1.13	***	1.13	***	1.24	***
	(0.03)		(0.03)		(0.03)		(0.03)	
Prop. Hispanic	1.46	***	1.46	***	1.46	***	1.36	***
	(0.04)		(0.04)		(0.04)		(0.04)	
Median Income	0.18e-4	***	0.18e-4	***	0.18e-4	***	0.18e-4	***
	(0.00)		(0.00)		(0.00)		(0.00)	
Median Income, Squared	-0.52e-10	***	0.52e-10	***	-0.52e-10	***	-0.53e-10	***
	(0.00)		(0.00)		(0.00)		(0.00)	
Prop. Manufacturing Workers	1.78	***	1.78	***	1.78	***	1.82	***
	(0.11)		(0.11)		(0.11)		(0.11)	
Prop. Owner-Occupied Homes	-1.41	***	-1.41	***	-1.41	***	-1.44	***
	(0.03)		(0.03)		(0.03)		(0.03)	
Population	-0.2e-4	***	-0.2e-4	***	-0.2e-4	***	-0.23e-4	***
	(0.00)		(0.00)		(0.00)		(0.00)	
Metropolitan Level								
Census Region (East ref.)								
South	0.23		0.58		-1.18	*	-1.18	*
	(0.42)		(0.43)		(0.47)		(0.47)	
Midwestern	1.05	**	1.28	***	-0.21		-0.21	
	(0.31)		(0.33)		(0.36)		(0.36)	
West	-1.09	**	-1.33	***	-1.13	**	-1.13	**
	(0.35)		(0.36)		(0.34)		(0.34)	
Residential Segregation	-0.63		0.94		1.91	**	1.91	**
	(0.78)		(0.83)		(0.61)		(0.61)	
Median Income	-0.62e-4	**	0.51e-4	**	0.8e-05		-0.8e-5	
	(0.00)		(0.00)		(0.00)		(0.00)	
Population, logged 1970	0.96	***						
	(0.16)							

Population, logged 2010		0.46 *		
		(0.18)		
Population Change 1970 to 2010			4.66 ***	4.66 ***
			(0.66)	(0.66)
Cross-Level Interactions				
Population Change x Prop. Black				-1.1 ***
				(0.1)
Population Change x Prop. Hispanic				-1.57 ***
				(0.13)
Level-1 *N*	363	363	363	363
Level-1 Variance	5.29	5.74	5.13	5.13
Level-2 *N*	58,780	58,780	58,780	58,989
Level-2 Variance	1.57	1.57	1.57	1.56
Intra-Class Correlation Coefficient	0.77	0.79	0.77	0.77

serve as a supplement to the models showcased for manufacturing workers. Model 1 tests to see if the population size in 1970 is associated with the toxic concentration, net of other factors. The coefficient for the logged 1970 population is positive and statistically significant, indicating that cities with larger populations in 1970 are associated with higher levels of pollution in 2010. Model 2 shows a similar relationship for population in 2010, and it is also statistically significant. This further points to how pollution outcomes in the present follow paths generated by past urban development.

Model 3 investigates population change from 1970 to 2010 on the 2010 toxic concentration. Results show that there is a positive, statistically significant link between this ratio and exposure to pollution. Places with declines in population or tepid population growth are associated with increased exposure to industrial air pollution. By contrast, urban areas with more population growth are associated with less toxic air. In this way, again, the 1970 population is a bellwether for even contemporary patterns of exposure to health risks from toxic air. Finally, Model 4 tests interactions between the change variable – in this case, population change from 1970 to 2010 – and the tract-level racial composition variables. The interactions between the ratio variable for proportion black and for proportion Hispanic show a negative association between these variables. This means that there is greater racial inequality in metropolitan areas with more population growth, and attenuated racial inequalities in places with population decline and lower population growth. This final finding also parallels the finding in Model 4 of Table 4.3.

4.4. Conclusion

The coevolution of industrial manufacturing and environmental degradation is most exemplified by the rise of cities. Findings from this paper suggest that the historical elements of this coevolution are critically important in the investigation of inequalities in exposure to toxic air. These findings can be summarized in five parts. First, there are large disparities across metropolitan areas in exposure to toxic air and little evidence from previous literature about how these disparities have come to be. Second, the 2010 proportion of manufacturing workers in a metropolitan area as well as the 1970 proportion of manufacturing workers are each positively associated with the presence of health risks from toxic air. Third, metropolitan areas that have had precipitous declines in manufacturing jobs are especially linked to greater toxic air. Fourth, urban areas with tepid or no population growth are similarly associated with increased exposure to toxic air. Fifth, cross-level interactions showcase that in the most polluted cities that have experienced declines in manufacturing workers have relatively smaller gaps in racialized pollution outcomes, but that racial inequalities remain even after accounting for metropolitan measures.

These findings suggest that previous approaches on metropolitan inequality (such as through spatial inequality through residential segregation studies) and on neighborhood inequality (such as most environmental justice research) remain incomplete and could be complemented with a place tradition perspective attendant to an environmental iron cage (Foster and Holleman 2012; Molotch, Freudenberg, and Paulsen 2000). That is, the lack of historical and longitudinal research on industrial pollution misses out on the origins of industrial pollution. An analysis of the composition of the manufacturing workforce aids in reconstructing how industrial history connects to contemporary patterns of pollution exposure. This important step acknowledges how environmental degradation is directly tied with how cultural logics of the rationality of capitalist production condition and constrain urban development.

For industrial pollution outcomes in particular, this paper makes two empirical and theoretical offerings. First, the historical composition of the metropolitan economy is critical to understanding present-day pollution exposure. Even the composition of the work force forty years previous to the measurement of the dependent variable is linked with health risks from industrial facilities. Second, metropolitan areas with declines in manufacturing are associated with higher levels of industrial pollution. Not only does this provide more evidence for the relevance of historical composition of the work force, it pushes it further. This second finding suggests that the industrial economy of the mid-twentieth century (and, likely, earlier than that) furnished cultural logics about industrial pollution that remain highly relevant. Even when there were declines in manufacturing jobs, these metropolitan areas maintained high levels of pollution.

Future research should explore why that is the case. It may be because the industry remains and that automation has taken over a relatively high share of the manufacturing work. In this way, it is not necessarily a weakening manufacturing economy in a place, but rather an increased efficiency of production—including of environmental ills. Or it may be the case that, with exogenous economic threats abounding in the form of globalization, local elites respond with a defensiveness of industry and a doubling down on place tradition surrounding that industry. Cities compete against one another in attempting to lure or retain growth (Logan and Molotch 2007), and particularly hard-hit places may opt to protect local industry at all costs, even as these industries move jobs (but not production) outside of that very place. In either case, the narrow focus on retaining polluting industries even without their jobs still produced pollution. Moreover, it points to the power of the iron cage as well as to the exploitation of land and labor for profits for a few.

This paper has limitations which promote avenues for future research. First, a more longitudinal study could be undertaken using the RSEI-GM that analyzes data from the full range presently available (1990 to 2015). This could help in more validly analyzing the historical arguments presented here. Second, the relationship of other economic factors across time – such as economic output from manufacturing or other industry types (e.g. finance) – could be generative sites with which to further analyze industrial pollution. Third, the theoretical perspective directly invokes cultural logics, but it is beyond the scope of this paper to directly identify the place-specific logics for metropolitan areas. Research should build on urban industrial and environmental histories as well as qualitative environmental justice research in this regard. It should also pay close attention to the role of civic and economic elites in doing so. Finally, it would be of interest to connect the theoretical perspective to other types of pollution, like those from transportation sources (Liévanos 2015) or smaller and medium-sized manufacturing facilities (Elliott and Frickel 2015).

Sustainable cities of the future must be guided toward those ends in the present. This research highlights that the past is prologue in this regard. Metropolitan industrial economies of times past sketch the introduction of the characters and plot of the present day. For the most polluted metropolitan areas playing out the dénouement of a manufacturing climax of decades past, critical questions and radical solutions must propose a new chapter.

CHAPTER FIVE: CONCLUSION

This dissertation examines the fate of chemical pollutants beyond that of the plume. Before chemicals from industrial facilities pass through the smokestack out into human settlements and before they are transformed in the manufacture of products we use every day, social processes are in motion. These social processes distinguish uneven geographies through which the chemicals travel.

Investigating the social processes that distinguish these uneven geographies is the core task of this dissertation. In particular, I highlighted the mechanisms in our metropolitan areas that condition these exposures to toxic air. The primary area of focus was on the civic capacity of cities, especially how social capital organizations and manufacturing history relate to differential impacts of industrial pollution.

In this chapter, I first summarize the findings of each of the core chapters. Following this, I offer a synthesis of these chapters by explicating a theoretical framework based on existing social theory and this dissertation's empirical findings. Much of this theory is contained in each of the chapters, but is presented in this chapter in a holistic version. In the concluding portion of this chapter, I suggest avenues for future research, particularly toward using pollution data for population health research, and for developing methodological programs for the analysis of metropolitan disparities in industrial pollution.

5.1 Summary of Dissertation

Chapter Two delves into the study of civic capacity and industrial pollution by examining the role of two different types of social capital organizations. The primary theoretical argument centers on the idea that the ways in which residents of a city are connected to each other is a fundamental fulcrum through which social action in an urban area is conditioned. Research on social capital organizations suggests that these organizations are clearinghouses for "bridging" or "bonding" social ties (Putnam 2000; Small 2009). Different types of organizations tend to have greater rates of bridging ties or greater rates of bonding ties. Organizations that have more bridging ties that connect group members to other groups and the wider community are considered "connected organizations," while organizations that have more bonding ties that bring group members together but do not include as many outside ties are considered "isolated organizations" (Kwon, Heflin, and Ruef 2013; Paxton 2007).

The analysis in Chapter Two tests to see if urban areas that have more connected organizations (and therefore more bridging ties in the metropolitan area) and that have more isolated organizations (and therefore more bonding ties) are associated with different levels of industrial pollution, and different patterns of racial inequality. The implication is that metropolitan areas with more connective social tissue may have better pollution and attenuated inequalities, and places where social capital isolates residents from one another may have more pollution and inequalities. This thesis is mostly supported. First, the presence of a greater density of connected organizations is associated with less toxic air in a metropolitan area, and a higher density of isolated organizations is associated with more toxic air in an urban area. This parallel but opposite findings suggest that the strength of social ties is linked to industrial pollution levels, and, further, that it depends on the nature of ties as well. Second, findings that test the implications of these two social capital measures as they relate to racial inequalities show that it depends on the social capital measure and the racial composition variable. Metropolitan areas with more connected organizations are associated with extended environmental inequalities especially for neighborhoods with more black residents, but with lessened inequalities for neighborhoods with more Hispanic residents. By contrast, more isolated organizations in a metropolitan areas are associated with extended inequalities for neighborhoods with more Hispanic residents. In total, these findings implicate the importance of a civic capacity perspective that analyzes the amount and nature of social ties across a community, and how this relates to the presence and inequalities in industrial pollution.

Chapter Three closely follows the same theoretical aegis and empirical framework as Chapter Two, but utilizes new data and more closely specified organizational measures. The primary focus is on three different types of religious organizations: Evangelical Protestants, Mainline Protestants, and Catholics. Religious organizations are a primary conduit of social capital in the United States (Iannaccone 1994; Putnam 2000; Welch, Sikkink, and Loveland 2007; Wuthnow 1999). But this line of research critically notes that the paths of social capital are not the same across all religious organizations (Beyerlein and Hipp 2005; Blanchard et al. 2008; Shihadeh and Winters 2010). For example, compared to Mainline Protestants or Catholics, Evangelical Protestants do not have as many connections to the wider community, but do create enduring connections within the organizations. Mainline Protestants and Catholics, on the other hand, tend to have more inter-organizational ties beyond church walls. In these ways, Evangelical Protestant congregations might be thought of as "isolated" organizations because of the insularity of ties, while Mainline Protestant and Catholic congregations could be considered "connected" associations because of the cross-cutting nature of their social ties.

The empirical models in Chapter Three test to see if each of these measures of the density of religious congregations are associated with overall levels of industrial pollution in a metropolitan area as well as the shape of racial inequalities within metropolitan areas. The findings at the metropolitan level showcase relationships between the social backdrop undergirded by religious organizations is linked to industrial pollution outcomes. Metropolitan areas with more Evangelical congregations are associated with more unhealthful industrially produced air pollution, which affirms the theoretical argument about the insularity of these isolated organizations' ties. No evidence is found for the association for Catholic congregations and Mainline Protestant congregations and levels of toxic air. The relationships for the interactions between neighborhood racial composition and metropolitan organizational measures further show these relationships. Metropolitan areas with more Evangelical organizations are associated with extended racial inequalities, but urban areas with more Mainline Protestant and Catholic congregations are associated with attenuated racial inequalities. These results more closely mirror the hypotheses expected with the connecting and isolating social ties that are initiated through these organizations.

Chapter Four investigates changes in the manufacturing sector in metropolitan areas, and how it relates to exposure to industrial pollution. Since the 1960s, the United States has seen a precipitous decline in manufacturing work, with many jobs moving overseas as a byproduct of globalization or simply becoming automated. Manufacturing jobs, especially at the neighborhood level, are often correlated with increased industrial pollution. This not-so-surprising relationship may be confounded across time as urban areas have lost (or, in some cases, gained) manufacturing work at rather different rates.

Moreover, because industrial pollution is a product of historical decisions about primary industries in a given place, I aver that the historical levels of workers may be just as important in determining present-day pollution exposure as today's measures of manufacturing workers.

Findings from Chapter Four showcase the proportion of workers in manufacturing occupations in a metropolitan area is linked to environmental degradation: more workers are associated with more pollution. This is true in shaping 2010 pollution outcomes not only for the 2010 composition of workers, but also the 1970 levels. Because of deindustrialization, I tested to see if urban areas with declines (or gains) in workers had any link to health risks from industrial facilities. The findings show that places with drops in manufacturing workers are associated with more toxic air in a metropolitan area. This finding suggests that the monolithic relationship between manufacturing and industrial pollution may yet be more complex, with the historical configuration of the economy playing a bigger role in contemporary pollution exposure as well as with changes across time playing a role as well.

5.2. Discussion of Findings

A synthesis of the findings across these chapters can be subsumed under the heading of a civic capacity framework. The civic capacity framework argues that the historical trajectory of place conditions the possibilities for social action (Molotch, Freudenberg, and Paulsen 2000). When considering environmental inequality and industrial pollution in particular, the perspective highlights how the urban and nature often conjoin in dialectical ways across time, by actors, and through institutions (Downey

2015; Foster and Holleman 2012). It also concerns how environmental risk is managed, maintained, and finally contested or tolerated (Elliott and Frickel 2015).

The perspective can be summarized thusly. With the industrial evolution in the United States in the nineteenth century, cities unmistakably bore the imprint of capitalist development (Engels 1844; Harvey 1973). This industrial imprimatur of specific places meant that cities became known for one or a few major industries. Examples include the closely coupled chemical manufacturing in Anniston, Alabama (Spears 2014), mining in Bisbee, Arizona (Carter 2014), and energy fortunes in "energy capitals" (Pratt, Melosi, and Brosnan 2014). While the degree to which a given place relied on such industries varied, many cities hewed to particular industries, some of them highly toxic ones. As evinced in their comparative study of the otherwise similar cities of Santa Barbara and Ventura in California, Molotch, Freudenberg, and Paulsen (2000) studied how Ventura doubled down on oil and gas industries in recent decades while Santa Barbara did not. Their perspective focuses especially on the role that historical actions have in structuring the possibilities for elite actions later in time.

This could be thought of as a Weberian "iron cage" where the cultural logics in pursuit of capitalist development find environmental degradation rational, and are constrained by place in determining any future paths (Foster and Holleman 2012). Social capital organizations are central to this insofar as they are historically determined groups that facilitate a range of possibilities for social action in a city. It might follow that the amount and type of ties present in a place will be conditioned by historical processes that in turn promote or discourage certain paths of actions. These organizations offer an institutional examination of the city in this way.

Therefore, historical trajectories of economy, organizations, and environment indelibly shape contemporary exposure to industrial pollution. Put somewhat crudely, levels of environmental degradation may have more to do with the historical relationships of city, economy, and society than with contemporary configurations of these elements. This provokes an important last point. Environmental regulation of industry in the United States did not begin in earnest until the 1980s, a time already well into deindustrialization. If historical trajectories of environmental degradation were already set into motion by the 1980s, then present-day environmental risks emerged from a time before then when communities did not have an adequate understanding of the pollution around them because of a lack of science on some pollutants or corporate inaction in sharing knowledge of toxins (Elliott and Frickel 2015; Spears 2014). The empirical findings in this paper point to one of industrial polluters' biggest risk containment strategy is that of continuing to pollute metropolitan areas that have been long polluted, and shying away from heavily toxic facilities in places with little or new industry.

5.3. Conclusion: Suggestions for Future Research

One of the core goals of this dissertation is to provoke a critical conversation about how industrial pollution is unevenly distributed across our cities. A key component of the conversation is that previous approaches have had limited utility investigating why this reality has come to be. The empirical evidence offered here likewise suggests that more research can be importantly conducted in the area of environmental inequalities across metropolitan areas. As a concluding thought, I identify two broad areas of research that deserve greater examination.

The first area that I suggest for future research concerns how the health risks outlined in this research more closely connected with population health outcomes. The study of environmental inequalities across metropolitan areas can be aided by discussing metrics beyond that of industrially produced toxic chemicals. Three ways in particular come to mind. First, the RSEI-GM has chemical-specific information about emissions that can be employed to closely conceptualize health risks. For example, instead of using an aggregate measure of health risks that takes into account more than four hundred chemicals, it might be of interest to focus on a specific chemical or family of chemicals. These data could be paired with geocoded individual-level health data to determine associations between chemical emissions and specific health maladies. It would be of particular interest to leverage longitudinal health data alongside more than a quarter century (1988 to 2015) of RSEI-GM data.

Second, an additional area of importance in the study of air pollution concerns fine particulate matter. Fine particulate matter is linked as one of the most harmful air pollutants – especially in the amount of particulate pollution – that affects human life. It is not measured among the RSEI-GM pollutants. Studying industrially produced particulate matter (as well as particulate matter from other pollution sources) could elucidate if disparities across places extent to this type of pollutant as well.

Finally, while the RSEI-GM concerns industrial air pollutants, it does leave aside other types of pollution (in addition to particulate matter), namely non-industrial air pollutants and land-based or water-based pollutants. Much of the theoretical scaffolding in this dissertation is built on the logic of capitalist-driven large industry. But there are many cases when environmental inequality and environmental justice concerns lie outside this realm. Examples include air pollution from automobiles, proximity to municipal waste facilities, or drinking water from toxic waterways. Testing the theoretical framework against data in these areas and beyond might augment research already occurring around these topics.

The second broad area of analysis hones in on industrial air pollution across cities, and methodologies that might further aid in investigation in why they have emerged. The data presented in this dissertation often centers around the same few dozen metropolitan areas. As seen in Chapter Two, ten of the largest and most toxic metropolitan areas had about a quarter of the industrially produced toxic air in the United States in 2012. Chapter Four illustrates that while 66 metropolitan areas have half or more of their neighborhoods in the upper quartile of the most toxic tracts, 139 metropolitan areas do not have any in that upper quartile. This dissertation utilizes a national lens with which to identify and analyze these disparities, but diving into mechanisms at play might be furthered with an analysis of a smaller subset of metropolitan areas, namely those among the most toxic in the United States.

A few ways to do so can be envisioned. First, case studies and environmental histories of these places could be fruitful. It could be done on one or a range of cities. Previous research about some of most polluted cities in the data powerfully show the utility of understanding the historical trajectory of environmental ills in a given place; examples include places like Anniston, Alabama (Spears 2014), Chicago (Cronon 1991; Pellow 2002), Houston (Melosi and Pratt 2007), and Philadelphia (Sicotte 2016). Using these as a point of departure, case study research might utilize strategically chosen pairs with similar attributes except that of pollution levels (e.g. Molotch, Freudenberg, and

Paulsen 2000; see also Paulsen 2004), or investigate cities from different U.S. regions that also share certain commonalities (e.g. Elliott and Frickel 2015). In any case, analyzing the conjunction of manufacturing history, social history, and governance in one or a few urban areas could help to elucidate mechanisms by which this phenomenon can be studied.

A second method of studying the most toxic metropolitan areas would involve the use of qualitative comparative analysis (QCA). These techniques often use rich data on a smaller number of cases to analyze how different "ingredients" (or variables) conjoin in the production of outcomes thereby creating a "recipe." This stands in distinction to regression techniques, which seek to find effects for single variables net of other measures. QCA has already been used in research on environmental inequality by examining how organizational and neighborhood attributes predict risky emissions recipes (Grant et al. 2010). An analysis of the few dozen most toxic metropolitan areas could involve additional data collection about the metropolitan areas using data that might be otherwise intensive to collect about all 363 metropolitan areas in the contiguous United States; alternately, using a carefully selected database of variables for both heavily polluted and relatively un-polluted areas could be used as well. In both of these approaches, qualitative comparative analysis could be used to see what it is about these extreme cases that structures the health risks for residents within those metropolitan areas.

In conclusion, this dissertation makes the argument for producing research on metropolitan disparities in industrial pollution. I offer evidence about the efficacy of a civic capacity perspective to fill in the larger picture of how these health risks have come to be. I also suggest avenues for future research on these topics that can aid in the study of environmental inequalities. Following these avenues will be critical in challenging environmental injustice.

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