ENVIRONMENTAL JUSTICE: THE ARIZONA EXPERIENCE

by

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Abstract

This work aims to determine the existence of a disparate impact of pollution on minority residents in Maricopa County, Arizona, caused by the siting decisions of polluting facilities as well as the household decision to move into polluted communities. Using US Census data alongside data from the EPA's Toxic Release Inventory (TRI), this paper finds evidence that *(1)* minorities in Maricopa County do suffer from a disparate impact from pollution and *(2)* that race is a significant predictor for the siting of a TRI facility and *(3)* the causality can be reversed as minority residents also move toward the pollution. These findings support assertions made by environmental justice advocates and broaden the existing literature by providing yet more evidence of minorities suffering a disparate impact from pollution and revealing that minorities tend to migrate toward polluted communities thus underscoring the need for community involvement in the process of policy development.

Chapter One – Introduction

Pollution is a pervasive issue in today's society and most people experience the effects of pollution to varying degrees. Studies reveal, however, that minorities and low income households are suffering a disparate impact from pollution. The Natural Resource Defense Council (NRDC) and American Lung Association recently released studies containing evidence supporting many environmental justice claims that not only are minorities and low income communities suffering from a disproportionate level of exposure to water, land, and air pollution, but they are indeed experiencing serious health risks associated with that pollution.

1.1 The Disproportionate Effects of Water, Land, and Air Pollution

The NRDC released a report in October 2004, revealing that on average Latinos are exposed to greater environmental health risks than the rest of the population. For example, along the US – Mexico border, 12 percent of the population lack access to potable water and 30 percent lack access to proper wastewater treatment. As a result, people living in these border towns often resort to drinking water from canals and wells which are contaminated with agricultural run-off, biological septic waste, and industrial waste[1]. Consuming polluted water such as this can lead to illnesses like cholera, giardiasis, and hepatitis. In these border towns, the rates of hepatitis A and

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[1] According to the NRDC report, the problem with industrial waste in border towns is compounded by the 4,760 American-owned factories, *maquiladoras*, along the Mexican side of the border responsible for much of the discharge contaminating surface water.

gastrointestinal diseases are two and three times the national rate, respectively (Quirindongo et al. 2004).

Furthermore, an econometric study of the distribution of National Priorities Listings, NPL, by John Hird reveals that Superfund sites, areas where money is pooled to commence clean-up of hazardous waste, are disproportionately located in wealthy counties with low poverty rates thus these wealthier communities stand to benefit more from clean-up than economically disadvantaged communities as funds are redistributed from consumers and taxpayers to the wealthy. Although the benefits of clean-up may not be far-reaching, the detriments of the ground contamination caused by these sites can affect thousands. Hird notes one site in particular, the Newmark Superfund site, located in San Bernardino, California, where the contamination of aquifers has affected the drinking water for hundreds if thousands of people (Hird 1993).

Perhaps exposure to air pollution most dramatically illustrates disparate impacts. Results from a recent poll in Arizona[2] by the Behavior Research Center revealed that 62 percent of households with incomes below $25,000 suffer from vision problems and breathing difficulties resulting from air pollution; whereas, only 44 percent of households with income higher than $65,000 suffer from similar ailments. The disparity could be the result of low income residents living in areas with poor environmental quality (Tobin 2005) which is reminiscent of the American Lung Association's report, briefly

[2] The poll was conducted statewide via telephone survey of 703 adults in January 2005.

summarized below in Table 1, which reveals that 65 percent of Blacks and 80 percent of Hispanics live in areas with poor air quality[3].

Table 1: Minority Exposure to Poor Air Quality

	Whites	Blacks	Hispanics
Live in areas with poor air quality[4]	57%	65%	80%
Asthma rate[5]	69.4	95.7	49
Asthma mortality rate	1.2	3.6	1.4

Source: American Lung Association

Air pollution can result in anything from minor eye irritation and sore throat to, more severely, an increased risk of asthma, lung cancer, allergies, chronic bronchitis and premature death. Pregnant women and children take the brunt of the risk with increased potential for premature birth, low birth weight and heart defects in newborns (Quirindongo et al. 2004). The American Lung Association claims that minority communities are more likely to live near areas experiencing heavy traffic, and work in places that expose them to hazardous chemicals, thus raising the risk of lung disease, which is significantly more common among communities of color (Szabo 2005).

1.2 The Evolution of Environmental Justice

Equity concerns have quite naturally arisen over the disproportionate exposure of minority and low-income communities to land, air, and water contamination. A hybrid of the civil rights and environmental movements, the concept of environmental justice

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[3] For example, residents living near "Refinery Row" in Corpus Cristi, Texas, suffer from disparate impacts from industrial air pollution where housing projects are located just across the road from refineries and a hazardous waste recycling plant. The communities in closest proximity to the facilities range from 40 to 89 percent Latino and African Americans make up most of the remainder; the cancer rate in this area is 17 percent higher than the rest of the city (Quirindongo et al. 2004).

[4] Poor air quality is defined as failing to meet air quality standards according to the EPA.

[5] Asthma rate is per 1,000 people and the asthma mortality rate is per 100,000 people.

began to make its way onto the political and legal scene in the 1980s. Although there is no single definition of environmental justice, the one proposed by Vicki Been and Francis Gupta (1997) is fairly thorough stating that low income and minority communities are exposed to greater environmental risks than other communities due to racism and classism through the *siting* of locally undesirable land uses (LULU's), the *creation* of environmental and land use regulations, the *enforcement* of those regulations, and, finally, the *clean up* of polluted communities. Gerard (1999) adds that minorities and low income individuals should be included in the decision-making process on issues that effect the environment in their communities.

After the historic report *Toxic Waste and Race in the United States* was released by the Commission of Racial Justice of the United Church of Christ in 1987 (UCC 1987), people began organizing and a flurry of legal activity ensued. Many of the early cases were unsuccessful due to the plaintiffs' inability to prove the defendants' intent to discriminate. In 1994 President Clinton signed an Executive Order addressing environmental justice as it applies to federal programs and by 1997, plaintiffs finally began winning some environmental justice cases as new doctrines emerged that no longer required the proof of intentional discrimination[6]. However, plaintiffs prevailing in environmental justice cases remain the exception, not the rule.

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[6] For example, in the 1998 case *Crawford-El v. Britton*, the plaintiff, a prisoner, claimed that the defendant, a corrections officer, purposefully misdirected his articles of clothing and legal materials in order "punish him for exercising his First Amendment rights and to deter similar conduct in the future." The District of Columbia Circuit Court of Appeals held that the plaintiff must have clear evidence that this violation was intentional. The Supreme Court, however, reversed claiming that this burden of proof is excessive for the plaintiff to bear.

1.3 Illustrative Environmental Justice Cases

The environmental justice realm is vast and the legal cases cover a wide range of issues. Typically the defendant is a regulatory authority charged with discriminatory decision making with respect to the siting, enforcement, or remediation of polluting facilities. One of the most egregious cases of disparate impact resulting from the siting of a waste facility is the case of *R.I.S.E. v. Kay*[7] in northern Virginia. In 1991, the Residents Involved in Saving the Environment (R.I.S.E.) asserted they were denied equal protection when the county board of supervisors approved a permit for a landfill in a predominately black community which R.I.S.E. claimed was part of a larger pattern of discrimination. The proposed landfill was to be located in an area that was 64% black, while the three other existing county landfills were in communities that were almost entirely black. There was one landfill, King Land, in the county located in a chiefly white community, but after only one year in operation it was promptly shut down due to violating zoning and environmental regulations (Gerard 1999).

The plaintiffs were unable to prove the county board of supervisors' intent to discriminate[8] and the court ruled that the board's approval of the landfill was based on the environmental suitability of the location, not the racial make up of the community.

In 1997, in *Alviso Citizens of Action v. City of San Jose*[9], residents of the low-income, Latino community of Alviso, which is adjacent to a Superfund site, filed suit due

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[7] A comprehensive discussion of the legal foundation for EJ claims is presented in Gerrard, 1999. A survey of salient issues is oresented in the following section.
[8] Under Equal Protection it is the burden of the plaintiff to prove there was not only a disparate impact but intent to discriminate. Chapter Two will discuss Equal Protection and other legal theories in more detail.
[9] The Environmental Law Foundation, ELF, filed the complaint on behalf of the Alviso residents and alleged 3 class actions: personal injury, nuisance for property owners, and nuisance for all residents.

to the lack of enforcement of environmental laws leading to the illegal dumping of asbestos in the wetlands in their community thus dramatically increasing the residents' risk of cancer. Most of the businesses operated illegally without the proper permits and many violated zoning laws; the largest polluter was operating illegally for 25 years without a single one of the required building or site permits. In this case, the court eventually sided with plaintiffs forcing the largest polluter to relocate and compensate Alviso residents. (Wheaton 2004).

Similarly, residents near Kingsly Park in Buffalo, New York, also suffered from contamination - this time from arsenic in the soil of a playground. Kingsly Park is located in the Masten District, a low income, minority neighborhood in Buffalo, where in 1983, the Erie County Department of the Environment found arsenic levels that were higher than normal but claimed that there was no immediate problem and there were no plans to continue the investigation (Thigpen 1993). Kingsly Park remained open as local residents experienced high rates of cancers, respiratory problems, rashes and fevers. In 1989, the state finally designated the site as a threat to public health but without a clean-up schedule. As Masten residents awaited the clean-up of Kingsly Park, in 1991, Bryant Homeowners Association successfully defeated a zoning request to build a medical waste incinerator in a predominately White, middle class neighborhood in Buffalo via expensive research methods to offer alternatives to the incinerator.

In 1990, residents organized and wrote letters to the EPA and the State Department of Health requesting new tests and clean-up. The new tests revealed arsenic levels of 7,090 parts per million (ppm); safe levels of arsenic are around 20 ppm. Clean-up finally commenced in 1991 (Thigpen 1993).

1.4 Common Ground of Environmental Justice Argument

All aspects of the EJ argument share a common denominator: low income and minority communities experience a disproportionate level of environmental risk. These risks may be posed by exposure to air, land, and/or water contaminates and can result from agency siting, enforcement, and/or remediation decisions. The crux of the successful environmental justice argument today lies in the ability to prove a disparate impact of environmental risk on a minority or low income community. The plaintiff no longer has to prove *intent* to discriminate, as in *R.I.S.E. v. Kay*; as of 1994, under Title VI, a disparate impact alone will spur further investigation. Still, environmental justice remains a contentious issue and various organizations have presented conflicting evidence on the topic. Much of the recent literature on the topic finds a link between minority and low income communities and substandard environmental quality although it has proven difficult to determine the causality of the relationship.

The empirical research in Chapter Four examines environmental justice in Maricopa County, Arizona, to determine *(1)* if minorities are suffering from a disparate impact from pollution, and *(2)* if the minority population is shifting toward polluted communities thus creating a disproportionate risk.

1.5 Organization of Thesis

This paper will be organized as follows. Chapter two will discuss the legal foundations for EJ claims as chapter three focuses, more specifically, on the administrative complaints procedure and the EPAs controversial Interim Guidance for handling such complaints. Chapter four follows with a review of prominent environmental justice literature, while the remaining chapters will discuss the empirical research for this paper including the model specification, data, and results in chapter five, followed by the conclusion and policy implications of this research in chapter six.

Chapter 2 - Legal Foundation for Environmental Justice Claims

Environmental justice advocates have employed different legal theories to varying degrees of success. Initially, environmental justice attorneys turned to the Constitution for protection, but instead of leveraging the Civil Rights Act of 1964 - a logical segue considering the EJ movement is a spin-off from the Civil Rights movement in the 1960s - advocates argued denial of equal protection under the 14^{th} Amendment which proved to be a Herculean task. This chapter discusses the legal theories and strategies employed by environmental justice advocates and it provides a backdrop to the complex administrative complaints process discussed in the following chapter.

2.1 Equal Protection: An Executive Summary

Section 1 of the 14^{th} Amendment states that no one in the United States should be denied equal protection of the laws. Since minorities are suffering disparate impacts from pollution, ultimately due to a lack of "equal protection" via environmental regulation, this is a seemingly logical argument. With few exceptions, however, the equal protection argument proved to be ineffective. The main obstacle to this legal argument is that proof of a disparate impact is not enough. There must also be evidence that the motivation behind the disparity is discriminatory. Without this proof of intent to discriminate, the disparity itself has no bearing on the claim of denial of equal protection.

In order to prove intent to discriminate, the plaintiff must provide evidence that the law was enacted with a discriminatory purpose or that a neutral law was applied in a discriminatory fashion. There are several ways to prove discriminatory intent, but most of them are difficult to document and have proven to be ineffective. First, if the disparity is so egregious that there is no doubt that the intent of the statute was discriminatory, then equal protection has been violated. The same is also true if there was an unusual shift in procedure which resulted in a disproportionate risk for minorities or if a seemingly neutral law was enforced in a discriminatory manner. Perhaps the most difficult proof to obtain demonstrating the intent to discriminate are actual statements from government or agency officials as many officials have privilege and these statements can be particularly difficult to document. In any case, the plaintiff often seeks injunctive relief or an annulment of agency determinations.

With limited success in the equal protection arena, the EJ legal strategy eventually shifted to Title VI of the Civil Rights Act of 1964 which prohibits discrimination by any agency receiving federal funding. Section 601 of Title VI presents many of the same hurdles for the plaintiff as the equal protection argument, so the attention quickly moved to Section 602 of Title VI where the EPA prohibits states from engaging in practices or distributing funds in ways that *cause* disparate impacts. So far, the EPA's Title VI regulations have proven to be the most effective way to challenge permits on the grounds of environmental justice (Gerrard 1999). Today citizens and EJ advocates continue to file administrative complaints with the EPA adding a severe burden on an all too often under funded agency. In an attempt to streamline the process, in 1998 the EPA issued a controversial document providing guidance for the proper handling of these administrative complaints which will be discussed in detail in the following chapter[10].

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[10] The remainder of this chapter discusses the aforementioned legal theories in detail. If the overview thus far of equal protection and Title VI is sufficient, the reader may wish to proceed directly to Chapter Three: The Administrative Complaints Process.

2.2 Constitutional Basis for Equal Protection

Environmental justice challenges discrimination at the government level and its Constitutional basis lies in Section 1 of the Fourteenth Amendment which asserts that states may not deny to any person within their jurisdiction the right to equal protection of the laws. In order to file an environmental justice claim under the umbrella of equal protection, a federal, state, or local government action must be involved. The plaintiff must prove that persons similarly situated are treated differently in an egregious fashion and the plaintiff must prove intent to discriminate (Gerrard 1999).

2.2.1 Judicial Scrutiny

Under equal protection, environmental justice cases are handled on a case by case basis subject to different measures of judicial scrutiny. One measure is the Rational Basis Test which states that the courts will uphold a statutory classification as long as some reasonable basis exists. One of the few examples of an invalidated classification is *City of Cleburne v. Cleburne Living Center* where a zoning law excluded group homes for the mentally retarded. The courts ruled that the law lacked a rational basis. Higher judicial scrutiny exists for suspect classifications like race or laws interfering with speech, voting, or access to justice[11] (Gerrard 1999).

The Supreme Court employs strict scrutiny for statutes, regulations, and other government actions that discriminate on race or national origin. In these instances, the burden rests on the government to prove that the law is narrowly designed to serve a compelling state interest. Courts consistently rule that laws that discriminate on the basis

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[11] The basis of higher scrutiny for race and basic rights is attributed to Justice Stone who included a footnote in the 1938 decision U.S. v. Carolene Products Co. It is the most celebrated footnote in Constitutional Law.

of race fail to satisfy the burden imposed by strict scrutiny. Environmental justice cases, however, can be more subtle as the laws are often written to be neutral but are applied or enforced in a discriminatory manner (Gerrard 1999).

2.2.2 Proof of Intent to Discriminate

Under equal protection, the plaintiff's burden lies with the need to prove a violation of the equal protection clause. In order to do so there must be evidence of both a disparate impact and also evidence of the government's intent to discriminate. In the case *Bean v. Southwestern Waste Management*, which was filed under the equal protection clause, the courts claimed there was neither a disparate impact nor proof of intent and ruled in favor of the defendant. Justice White asserted that "the invidious quality of a law claimed to be racially discriminatory must ultimately be traced to a racially discriminatory purpose" (Gerrard 1999). Disparity without proof of intent is not a violation of equal protection.

The evidence of intent can be proved circumstantially in two ways: first, if the law was enacted with a discriminatory purpose and, second, if a neutral statute has been applied in a discriminatory manner. For example, in the 1886 case *Yick Wo v. Hopkins*[12], a neutral law aimed at preventing fires in laundries was enforced only for Chinese laundries. The Supreme Court declared the law unconstitutional in violation of equal protection. Since the enforcement of this neutral law was egregiously disparate, this case also proved discriminatory intent was clearly established.

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[12] This was the first time the Supreme Court inferred discrimination in a law's enforcement.

2.2.3 Approaches to Proving Intent

There are four approaches to proving intent to discriminate. The plaintiff can show proof of a sufficiently disparate impact, discrimination in enforcing the statute, a shift in agency procedure, or proof of actual statements demonstrating intent to discriminate.

2.2.3 (a) Greatly Disparate Impact

A greatly disparate impact is defined as a sufficiently disparate impact on different races and is strong circumstantial proof of intent. But this egregious intent to discriminate can be difficult to prove under equal protection. It is also important to note that societal discrimination does not constitute proof of denial of equal protection by a specific government agency and often the general question arises in response: Was the policy decision based on race or environmental suitability? (Gerrard 1999)

An example of a successful claim of a greatly disparate impact is the 1971 decision *Hawkins v. Town of Shaw* where 60% of the town was Black and 98% of the unpaved streets in town were in Black neighborhoods. The plaintiff was able to prove not only that there was a greatly disparate impact, but also intent to discriminate.

2.2.3 (b) Discrimination in Enforcement of Statutes

The case of *Yick Wo v. Hopkins* is rare; in general, environmental justice suits have failed to show discrimination in applying neutral laws. In *Beasley v. Potter* in 1980, a Black-owned business was denied a permit to build an asphalt plant. The plaintiff claimed that a similar permit was awarded to a White-owned company. The court ruled that there was no discriminatory enforcement since the White-owned company was not in an agricultural district and was also protected under current zoning (Gerrard 1999).

2.2.3 (c) Shifts in Procedure

Deviations from normal governmental procedures may also imply intent to discriminate. An illustrative example of shifts in procedure is *United States v. Yonkers Board of Education* in 1987. The city of Yonkers rezoned parcels upon the prospect that public housing was imminent; this was sufficient circumstantial proof of intent to concentrate all public housing in existing minority areas (Gerrard 1999).

2.2.3 (d) Statements of Intent to Discriminate

Perhaps the most difficult way to prove intent to discriminate is via statements by officials or witnesses. This strategy is particularly difficult because it requires testimony by officials that is often barred by privilege and statements by officials or witnesses can be difficult to document. There have, however, been cases exhibiting brazen comments by officials and constituents. In *U.S. v. Yonkers Board of Education* almost all councilmen acknowledged that community opposition to the projects was race related and one councilman testified that his constituents were opposed because “they didn’t want any blacks [sic] there” (Gerrard 1999).

2.3 Asserting Equal Protection Claims

The most common avenue for asserting equal protection claims is to file suit under 42 U.S.C. § 1983[13]. Although the state itself cannot be sued[14], state officials and

[13] 42 U.S.C. § 1983 was enacted in 1871 and states that any “person who, under color of any statute, ordinance, regulation, custom,…subjects, or causes to be subjected, any citizen …to the deprivation of any rights…secured by the Constitution and laws…liable…in an action at law [or] equity…”

agencies can be sued in federal court[15]; however, judges and prosecutors have absolute immunity. According to the 11th Amendment[16], which asserts sovereign immunity, damages cannot be collected from states. There is one exception: under specific statutes designed to enforce the 14th Amendment. As a result, environmental justice suits often do not seek damages; instead most EJ suits request injunctive relief or an annulment of agency determinations[17] (Gerrard 1999).

Since the equal protection clause requires not only the proof of intent to discriminate, only the most egregious EJ cases were successful using this argument. For most cases, it proved to be a very difficult and ineffective vehicle to pursue an environmental justice suit. Seeking an alternative, EJ advocates eventually turned to Title VI of the Civil Rights Act of 1964 which proved to be relatively more successful.

2.4 Title VI

Title VI of the Civil Rights Act forbids discrimination by programs receiving federal funding and it has proved to be the best opportunity for citizens to bring environmental justice complaints against state or local agencies (Gerrard 1999). For example, if the Arizona Department of Environmental Quality (ADEQ) receives funding

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[14] In the case where a plaintiff decides to sue a federal funding recipient directly, he or she may use the discovery process, present evidence and witnesses, and cross-examine the defense witnesses. The plaintiff may also receive damages in addition to terminating the recipients' funding. Standing is established if the plaintiff shows he or she is harmed by the discriminatory practice (Gerrard 1999).

[15] Although most environmental justice suits are brought to federal court, claims may also be litigated in state court. States may interpret Constitutional rights more, but not less, broadly than at the federal level.

[16] "The Judicial power of the United States shall not be construed to extend to any suit in law or equity, commenced or prosecuted against one of the United States by Citizens of another State, or by Citizens or Subjects of any Foreign State." Amendment XI

[17] Environmental justice suits are subject to the states' statute of limitations and standing. Once a final decision regarding the parcel is made, the clock is set in motion for the statute of limitations. Standing is a more complicated issue. For the plaintiff to have standing, he or she must show actual or imminent injury and that injury must be direct, but not necessarily pecuniary (Gerrard 1999).

from the EPA, it is subject to Title VI jurisdiction. Under Title VI, a private citizen would sue the ADEQ instead of the permitee.

2.4.1 Sections 601 and 602

Section 601[18] of Title VI is reminiscent of the equal protection argument in that it requires the plaintiff to prove the government's intent to discriminate. Much like equal protection, suits filed under Section 601 tend to be ineffective for environmental justice claims.

As a result, the attention quickly shifted to Section 602[19] of Title VI which states that federal grant agencies may promote regulations prohibiting recipient state and local agencies from promoting discriminatory effects. Under Section 602, the EPA prohibits states from engaging in practices or distributing funds in ways that cause disparate impacts. The EPA's Title VI regulations have proven to be the most effective way to challenge permits on environmental justice grounds (Gerrard 1999).

There is, however, the unresolved legal issue of whether or not Section 602 creates a private right of action under which plaintiffs can file claims in federal court or if they are just filing an administrative complaint with a federal agency like the EPA. Regardless of how this issue of private right of action will be resolved, citizens continue to file administrative complaints with the EPA. In 1998, the EPA even issued a

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[18] "No person in the United States shall, on the ground of race, color, or national origin, be excluded from participation in, be denied the benefits of, or be subjected to discrimination under any program or activity receiving Federal financial assistance." 42 U.S.C. § 2000d.

[19] "Each Federal department and agency which is empowered to extend Federal financial assistance to any program or activity, by way of grant, loan, or contract…is authorized and directed to effectuate the provisions of section 2000d of this title with respect to this program by issuing rules…which shall be consistent with the achievement of the objectives of the statute authorizing the financial assistance." 42 U.S.C. § 2000d-1.

document providing guidance for the proper handling of administrative complaints (Gerrard 1999).

2.4.2 The EPA's Title VI Regulations

In 1999, the EPA funded 44 different programs, totaling about 1,500 recipients, in the amount of $7 billion. All of these programs are subject to Title VI jurisdiction. In addition, any state receiving EPA funding receives no 11th Amendment immunity. States have been required to comply with the EPA's Title VI regulations to prohibit discriminatory effects since 1973; however, the EPA failed to enforce their own Title VI regulations from 1973 to1993, claiming that it undermines programs to decrease pollution (Gerrard 1999).

Then in 1994, President Clinton signed an Executive Order[20] requiring the EPA to compel compliance with Title VI regulations. From 1993 to 1998, the EPA received 58 EJ complaints, 31 of which were rejected, 15 were being investigated, and 12 were pending investigation as of 1999 (Gerrard 1999). The reason for the EPAs sluggishness is twofold: not only do they lack the resources to appropriately review each complaint filed, but proving that a community is suffering from a disparate impact has proven to be a lengthy and difficult process riddled with technicalities and subjectivity. In order to streamline the processing of administrative complaints, the EPA developed the *Guidance for Investigating Title VI Administrative Complaints Challenging Permits*, which is subject to much criticism and will be explored in more detail in the following chapter.

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[20] On February 11, 1994, President Clinton signed Executive Order No. 12,898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations.* See http://www.epa.gov/compliance/resources/policies/ej/exec_order_12898.pdf

Chapter 3 – EPA's Administrative Complaint Process

3.1 Filing an Administrative Complaint Under Title VI

Filing a complaint under Title VI is relatively easy compared to the procedure under equal protection. A private citizen or organization (no lawyer is required) simply files a letter claiming that a recipient of federal funds is engaging in discriminatory practices (Cole 1994). He or she must file within 180 days of the discriminatory action, although there are exceptions[21]. The complainant, however, has no formal right to participate in the proceedings, there is no time limit on the EPA's response,[22] and no damages can be awarded (Hammer 1996). The EPA can only terminate federal funding and as they displayed in the time prior to Clinton's Executive Order, they are hesitant to do so (Cole 1994). Also there is limited opportunity to appeal and the courts invariably defer to an agency's prosecutorial discretion in deciding not to enforce a statute (Colopy 1994).

After receiving a complaint, the EPA will first notify the recipient and the complainant in writing within five calendar days as an acknowledgement. If the OCR accepts the complaint to conduct further investigation, they will notify both parties within twenty days after the initial acknowledgement and conduct a preliminary investigation to determine the presence of adverse disparate impact.[23] On the other hand, if the complaint does not meet criteria for further investigation by OCR, it will be referred to the appropriate office or the complaint will be rejected (Revez 2004).

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[21] The EPA may waiver the 180-day limit for "good cause" but often they are not sympathetic to such requests unless the complainant's request is delayed due to exhausting other channels and the complaint is filed in a timely manner once the request is granted.

[22] The statute of limitations on Title VI as well as other civil rights cases are equivalent to the state's personal injury statute of limitations. See Rozar vs. Mullis, 85 F.3d 556 (11th Cir. 1996).

[23] This process will be discussed in further detail later in this chapter.

First the EPA must first assess applicability. If the complaint is valid, the scope of the investigation must be defined by determining the nature of the impact, reviewing available data, and developing a project plan in order to conduct an impact assessment. If the impact is not adverse, then the investigation will be closed; otherwise, the EPA must then examine the demographics of the population and make comparisons to determine if a disparity exists and, if so, if it is significant (Revez 2004). The EPA then has the option to dismiss the complaint or deny, suspend, or terminate agency funding if the recipient is engaged in a discriminatory act. If successful, the complainant is entitled to lawyer's fees[24] and the recipient has the option to appeal to an administrative law judge (Gerrard 1999).

Whereas filing a complaint is relatively straightforward for the plaintiff, the effectiveness of the administrative complaints process on the EPA's side remains litigious: as of November 2003, only 17 of the 143 administrative complaints received over the previous ten years satisfied the criteria required to launch a preliminary investigation and only one went on to be adjudicated by the EPA[25] (Faerstein 2004).

However, it is important to bear in mind that it is the burden of the EPA's OCR to conduct the research to determine if an adverse disparity exists, which is a complicated and lengthy task requiring a great deal of resources. As a result, the OCR strongly encourages community involvement in order to identify and resolve public concerns early to preempt Title VI complaints, and industry is also encouraged to take voluntary

[24] See Civil Rights Attorney's Fees Awards Act of 1976, 42 U.S.C § 1988(b).

[25] The single case that was adjudicated involved the Select Steel facility in Flint, Michigan. The complaint was dismissed by the EPA stating that the recipient was in compliance with Title VI and even exceeded the requirements for public notice and participation. See Letter form Ann E. Goode, Director, EPA's Office of Civil Rights, Re: EPA File No. 5R-98-R5 (October 30, 1998).

initiatives to ensure compliance with Title VI. The EPA also emphasizes the benefits of informal negotiation and resolution techniques as a successful and desirable alternative to filing a complaint with OCR. To that end, OCR often persuades complainants and recipients to employ such techniques for resolution thus the number of cases actually being resolved may be artificially low since they are reaching agreements using other means. This way, OCR can allocate its meager resources most efficiently. For the complaints that do require investigation by OCR, the EPA prepared a rather controversial document to provide guidance for the EPA to navigate uncharted territory (Revez 2004).

3.2 EPA's Guidance for Investigating Title VI Administrative Complaints Challenging Permits

In 1998, the EPA released the *Interim Guidance for Investigating Title VI Administrative Complaints Challenging Permits* in order to provide a basis for the Office of Civil Rights to process such complaints[26]. The scope of the *Interim Guidance* was not to provide a solution for every single set of circumstances, but to provide a basic framework from which the OCR can proceed on a case-by-case basis. Also, the EPA encourages the use of negotiation as an informal solution to many of the complaints filed (Revez 2004).

There was much criticism, however, in the wake of the *Interim Guidance'* ninety day period for public comment. So much, in fact, that the EPA planned to have a revised version ready by 1999 incorporating suggestions from the commentary period. Many criticized that what is required by the *Guidance* is too onerous, too vague, and impedes

[26] See EPA, Interim Guidance for Investigating Title VI Administrative Complaints Challenging Permits, February 1998. See also Cheryl Hogue, *EPA Issues Guidance for Investigating Claims that State, Local Permits are Discriminatory,* 66 U.S. Law Week (Legal News), February 24, 1998.

economic development in minority communities. The document fails to clearly define what constitutes a "disparate impact", the required magnitude of said impact to be considered adverse, or who is considered the "affected population" (Hogue 1998). In July 1998, several members of the US Conference of Mayors expressed concern to Carol Browner, then EPA Administrator, that the EPA's *Guidance* will prohibit job growth in minority communities although many civil rights and minority organizations like the Congressional Black Caucus support the *Guidance* (Hogue 1998)[27].

3.3 The Adverse Disparate Impact Analysis

The *Draft Revised Guidance for Investigating Title VI* provides a six step procedure for analysis of the affected population emphasizing that each case is unique and may deviate from the suggested analytical framework.

Step 1: Assess Applicability

First, the OCR will determine the type of permit being contested. For example, a modification permit may be treated differently than a new permit, or the community may already have a specific agreement in place to reduce the effects of the disparate impact being challenged. Furthermore, the OCR must determine if the permit will have a significant effect on reduction of overall emissions from a facility or on reduction of a specific pollutant being released. If the permit results in the reduction of cumulative emissions, then the case will probably be closed; otherwise, it will move to the next step in the process.

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[27] *See also* Jefferey B. Gracer, *Taking Environmental Justice Claims Seriously*, 28 Environmental L. Rep. (New and Analysis) 10373 1037 (July 1998); *Environmental Council of States Resolution on EPA Interim Guidance for Investigating Permit Challenges Approved March 26*, 1998, 59 Daily Env't Rep. (BNA) E-1 (March 27, 1998).

Step 2: Define the Scope of the Investigation

In this step, the OCR determines the source and impact of the stressors and which stressors should be included in the analysis. It is here that they also review the data and establish the project plan. As Revez notes, the OCR will rely on four key pieces of information in order to determine the scope: the complainant's allegations, the understanding of the recipient's authorities, relevant scientific information, and available data (2004). Once the scope is determined, the OCR will conduct an impact assessment.

Step 3: Conduct Impact Assessment

This next three sections of the *Guidance* may be the most important and controversial part of the analysis and also the most difficult due to the lack of consistent information and the various methodologies available. Here, the OCR must determine if the emissions from a permitted facility are likely to create a disparate impact whether alone or in combination with other sources. In order to do so, the EPA must quantify potential impacts using the best available data. Finding the best available data, however, can be a challenge. The same type of data may not be available in all cases so that evidence for each case will vary depending on the geographic area and the pollutant's medium. In some cases, there may not even be sufficient data to perform the impact analysis at all (Revez 2004).

Since the reliability of the impact analysis is weakened by its variability in the data, the EPA weighs information differently when making decisions[28]. Rarely do they

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[28] The OCR submitted several of its impact assessment methods to the EPA Science Advisory Board for review. A report of the findings, *An SAB Report: Review of Disproportionate Impact methodologies; A Review by the Integrated Human Exposure Committee (IHEC) of the Science Advisory Board (SAB),* can be found at http://www.epa.gov/civilrights/investig.htm.

find a direct link from the pollutant to adverse health effects of the affected population as this requires years of geographically specific health and environmental data which is rarely available. An alternative is performing a risk assessment where the risk of adverse health effects is predicted via modeling or monitoring the polluter. The OCR can then determine the toxicity; for example, the probability of cancer rates in the area as a result of the pollutant or combination of pollutants released (Revez 2004).

Another approach for impact assessment is the use of toxicity weighted emissions; this is the method used in the empirical chapter of this paper. In this instance, the EPA begins with chemicals that are known to be toxic and therefore likely to cause adverse health effects. The EPA then sums the emissions of such chemicals from various sources in a given geographic area; each source of pollution is assigned a score which is weighted by the toxicity of the chemicals released and amount released. This way, the OCR can link which sources are the most risky and can be indirectly linked to adverse health effects in a community. The OCR also has the option of using the ambient concentration in an area and then comparing those concentration levels to a benchmark which may be a less quantitative measure than the previous methods (Revez 2004).

Step 4: Adverse Impact Decision

It is here that the OCR must determine if the impact determined in step three is significantly adverse; if it is not, then the case will be closed. The findings of the impact assessment will be compared to benchmarks established by EPA's policies or regulations in order to determine the level of significance. For example, if the OCR finds that the cancer risk in an affected region is greater then one in 10,000 where the benchmark risk is one in one million, then there is an adverse effect and the OCR will proceed with their assessment. It is important to note here that such results do not necessarily imply a violation of Title VI; they simply provide cause to continue with the investigation. However, as Revez points out, compliance with environmental regulations also does not necessarily mean that there is no violation of Title VI since a seemingly neutral law can have discriminating effects; a recipient of a permit must comply with Title VI *in addition to* compliance with Federal or state environmental regulations. So if a facility complies with emissions regulations, they are still subject to further scrutiny and may still be in violation of Title VI (Revez 2004). The next step is to determine if the affected population is suffering a disproportionate risk

Step 5: Characterize Populations and Conduct Comparisons

Once the adverse impact of emissions is established, the OCR then must determine the demographics of the affected population and conduct a comparison with a similar population on the basis of race, color, national origin, and adverse impact in order to determine if a disparity is present. Upon identifying the affected population, it is important to note that it may not be the population that is in closest proximity to the source. Due to environmental factors like wind direction, topography, and water flow, emissions may not be evenly distributed; therefore, the affected area may be irregularly shaped. The OCR will use mathematical models, when possible, to estimate these areas (Revez 2004). This step proves to be yet another daunting task due to thin data and the unique circumstances of each case.

When the OCR is unable to utilize mathematical models, more simplified methods have been employed. One method, which is used for the empirical research in chapter five of this work, is to use proximity to the source for emissions released into the air. Using a radius around the facility, as the distance increases, the impact on the population decreases thus creating a proxy for the population that is most affected, which is the population surrounding the facility on all sides. Within that population, the OCR then determines the demographic composition of that area using U.S. Census data in the smallest resolution possible like census blocks[29] (Revez 2004).

Once the OCR has established the affected area and the demographics of that area, they must compare that affected population to a control population in a similar region. The control group is usually larger than the affected population and may or may not include the affected population itself as part of its constituency (Revez 2004).

Unfortunately, what constitutes a disparate impact according to the *Guidance* is vague since there are multiple applicable analyses, but the OCR contends that the comparisons deemed appropriate will vary depending on the uniqueness of each complaint. However, at least one of following will be assessed: the demographics of the affected population compared to those of an unaffected population, the demographics of the most likely to be affected versus the least likely to be affected, and the probability that a specific group (i.e. Non-white Hispanics) will be in an affected area. In addition to the demographic assessment, the OCR will also examine the risk level using either the

[29] For the empirical research in this paper, the *block group* is used from the U.S. Census which is one grade larger then the block. In this paper, the Census data is used to measure a change over time from 1990 to 2000, and the block definitions had too much variation over the ten year period for a meaningful comparison.

average risk or the *range* of risk of adverse impact for those within the affected area relative to the general population's risk level (Revez 2004).

Step 6: Adverse Disparate Impact Decision

This sixth and final step will determine if the disparity found in step five is significant; if it is not, then the case will be dismissed. As mentioned previously, the significance level will vary depending on the circumstances of each case. However, the OCR will consult with statisticians to review the results of the disparity analysis in order to account for uncertainties like organic variations in the data or accuracy of predicted levels of risk. The OCR reiterates that the results are often unclear and need to be evaluated on an individual basis (Revez 2004).

If the EPA does find that a disparate impact exists after completing this six step analysis, the agency that awarded the permit has 3 options: they can either *(1)* contest the EPA's findings, *(2)* develop a plan for mitigating the impact of the pollution, or *(3)* provide a substantial, legitimate justification for the facility and how the benefits of the facility far outweigh the costs of the disparate impact. EPA encourages mitigation and states that recipients should work with agency officials to determine when mitigation is appropriate and also to develop mitigation plans that extend into the future and beyond the scope of the permitting process so that the affected community is compensated (Gerrard 1999)[30].

The following chapter will add dimension to the EJ argument with a discussion of prominent environmental justice literature and criticisms of various methods of

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[30] See also EPA, Interim Guidance for Investigating Title VI Administrative Complaints Challenging Permits, February 1998.

measuring a disparate impact. In chapter five, empirical research is presented that attempts to demonstrate steps three, four, and five of the *Revised Guidance for Investigating Title VI Administrative Complaints Challenging Permits* and it presents some of the methodologies and challenges faced in completing an impact assessment.

Chapter 4 - Empirical Evidence on EJ: A Review of Prominent Studies

Since the inception of the environmental justice movement there has been a flurry of empirical evidence, much of which substantiates environmental justice advocates' claim that there is a correlation between minorities and disproportionate environmental risk. Adding depth to the debate, recent empirical work has gone a step further to find out *why* this correlation exists; researchers test a theory of market dynamics to determine if the changes in the demographic make-up of a community result from the presence of a polluting facility in the community. Although much of the research does support the claim of a disparate impact, there is mixed empirical evidence of the effects of this market dynamics theory. Also, these results are often sensitive to community definitions and measures of exposure, both of which have been the focus of some debate in the recent literature. Early empirical work on the topic may have lacked the sophistication of recent studies, but it proved to be an effective tool to spur and ongoing debate that is still relevant today.

4.1 Early Empirical Studies

In 1982 in Warren County, North Carolina, a polychlorinated biphenyl (PCB) landfill was sited in an African American community sparking nonviolent demonstrations and leading to over 500 arrests of protestors claiming that the community was targeted for the site because it is predominately Black[31] (Gauna et al 2003). These highly publicized protests eventually led to the General Accounting Office's investigation of the

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[31] According to Robert Bullard, the PCB site in Warren County was not the most environmentally suitable due to its shallow water table and the fact that most of the drinking water in the community is supplied by local wells. See http://www.ejrc.cau.edu/warren%20county%20rdb.htm. Last accessed 7/2004.

southern region[32]; they found that three of the four hazardous waste facilities were indeed located in African American communities but African Americans comprised only one fifth of the region's population (GAO 1983). Around the same time, Professor Robert Bullard published research on the demographics surrounding solid waste facilities in Houston; he found that 84% of solid waste facilities were located in predominately African American communities despite the fact that Blacks made up only 28% of the population in 1980 (Bullard 1983).

Several years later in 1987, the United Church of Christ's (UCC) Commission for Racial Justice produced a study at the national level using five digit zip codes as community definitions. Using percent minority population, mean household income, and mean value of owner-occupied housing as explanatory variables, they find a consistent national pattern of a highly significant correlation between race and the location of Treatment, Storage, and Disposal Facilities (TSDFs) and uncontrolled hazardous waste sites. Their results reveal that the communities with the most TSDFs also had the greatest share of minorities, communities with two or more sites had three times the share of minorities than communities without facilities, and communities with the presence of one site had twice the minority population of communities without hazardous waste sites. Also worth noting, is that race is more significant than socio-economic status even when controlling for urbanization and regional differences, and, according to the report, three

[32] Representative Walter Fauntroy (D-DC), who was arrested at the Warren County protests, urged the GAO to conduct research on the correlation between Blacks and hazardous waste sites in EPA Region IV, consisting of Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, and Tennessee.

out of five Blacks and Hispanics lived in communities with uncontrolled toxic waste facilities (UCC 1987).

In his review of 64 EJ studies, Benjamin Goldman (1994) also found race to be a more significant predictor of pollution than income.[33] Furthermore, Paul Mohai and Bunyan Bryant conducted a similar exercise and reviewed 15 early EJ studies to summarize the evidence brought to light as of 1992. They also found that when both income and race are accounted for, race often times proves to be a stronger predictor of pollution than income. They also noted that although the studies conducted were of varying scopes, from urban areas to the national level, the results consistently revealed a pattern of a disparate impact of pollution on minority populations and they concluded that the results of these studies can be generalized (1992).

4.2 Empirical Evidence: Toxic Storage and Disposal Facilities

Building on early empirical evidence, researchers in the 1990's conducted studies on environmental justice using new Census data and different methodologies. The UCC report was updated in 1994 by Goldman and Fitton using new 1990 Census data and zip codes as community boundaries and their results are consistent with the UCC report that communities hosting a TSDF site have more than two times the share of minorities than communities with no such facility. Goldman and Fitton also find that between the years 1980 – 1993, the concentration of minorities living in a host community increased (1994).

[33] When Goldman compared race to income for significance, in 22 out of 30 studies, race was a more significant indicator of pollution than income.

That same year, an opposing national study was released using the same 1980 Census data as the UCC, but using census tracts for community boundaries instead of zip codes. Anderton and his researchers find no statistically significant difference between the share of Blacks and Hispanics in host tracts versus non-host tracts. Census tracts are used in lieu of zip codes because the units "are [a] smaller and more refined…statistical subdivision of a county with clearly identifiable boundaries and a relatively homogeneous population of about 4000 persons" and the boundaries are defined by locals who are familiar with the neighborhoods in the area (Anderton et al 1994).

Anderton et al. compares census tracts with TSDFs to tracts without TSDFs but limits those tracts to only Standard Metropolitan Statistical Areas (SMSAs) that contain at least one TSDF. To account for the minority population they use percent Blacks and percent Hispanics and to explain socio-economic status the following variables are used: percent of families below poverty level, percent households receiving public assistance, percent employed males in civilian labor force, percent employed in manufacturing and mean housing stock (Anderton et al. 1994).

T-tests reveal no significant difference in the median percentage of Blacks or Hispanics in host tracts versus non-host tracts. Results are similar for households below the poverty line, and households receiving public assistance; however, mean housing value is significantly lower in tracts hosting waste facilities. Their results do show that the mean and median percentages of people employed in precision manufacturing are much higher in census tracts hosting a TDSF than those without a TSDF and regression analysis reveals that employment in precision manufacturing is a significant predictor of TSDFs whereas race is not (Anderton et al 1994).

Upon analyzing the areas surrounding a TSDF site, the authors find that TSDFs tend to be located in tracts that experience high levels of industrial activity and that census tracts surrounding those industrialized areas have higher concentrations of minorities and low income residents. This finding may explain why using larger geographic units like the zip codes used by the UCC and Goldman and Fitton revealed a significant correlation between TSDFs and minorities; the larger unit of measure could be masking local differences if minorities and low income residents generally tend to live in industrialized areas within the city (Anderton et al 1994).

Using 1980 Census data, the results do not lend support to the environmental inequity claim. However, when Anderton et al. conducts the same study using 1990 Census data, they find a significantly higher percentage of low income households and households on public assistance located in tracts with TSDF sites than those without (July 1994).

Anderton et al. used only metropolitan areas in the U.S. that host at least one facility under the assumption that those not currently hosting a facility are not suited to do so (Mohai 1995). Paul Mohai posits that just because an area is rural or not currently hosting a site does not exclude it from consideration and by narrowing the sample Anderton does not address the fact the SMSAs hosting waste facilities simultaneously have high concentrations of minorities thus reducing the probability for racial disparity (Mohai 1995). Also, Anderton et al. only accounted for Blacks and Hispanics in the minority population thus excluding 11% of the minority population in the U.S. (Gauna et al 2003).

In the spirit of Anderton et al, Vicki Been and Francis Gupta (1997) examine the siting of TSDFs also using the census tract as the geographical unit of analysis at the national level. Whereas Anderton et al. may have improved upon the UCC study by using the smaller census tracts in lieu of zip codes, as Been and Gupta point out, the use of census tracts as a geographical unit of analysis can also be problematic. Census tracts vary in size and shape and the waste facilities can be located anywhere within each tract so that different parts of the tract are affected differently. Also, facilities are frequently located near the boundary of a tract. Treating the host tract as the "affected" community, when it is the neighboring community that is significantly affected, can introduce noise into the model which is not accounted for by Been and Gupta (Walsh et al. 2004).

Been and Gupta make a significant contribution to the environmental justice literature by also examining the market dynamics theory to determine if the disparate impact revealed in previous studies is due to the siting of TSDFs or subsequent changes in the minority composition of the host communities (Been and Gupta 1997).

When comparing the means and distributions in host versus non-host tracts from 1970 to 1990, Been and Gupta find little evidence that African Americans are experiencing a disparate impact due to the siting of TSDFs; however, they do find that facilities sited in the 1970's were in areas with above average percentages of Hispanics (1997).

Been and Gupta also use a logit model with the absence or presence of a TSDF as the dependent variable and percent minority, mean family income, median housing value, population density, and the square of the percent minority, as explanatory variables. She finds no evidence that Blacks or low income families are disproportionately affected by the siting process. In fact, poverty is a negative and significant indicator for host tracts in 1980 suggesting that very poor communities lack the infrastructure to support such a facility and therefore may actually repel facilities[34]. The logit analysis does reveal that Hispanics are disproportionately affected by the siting process in 1970 and 1980; the percentage of Hispanics in a census tract is positively and significantly correlated with the probability that the tract hosts a TSDF (Been and Gupta1997).

When Been and Gupta compare the means of only the 1990 census demographics of the 544 host tracts to the 60,000 non-host tracts, they find that Blacks and Hispanics are both positively correlated and significant indicators of the presence of a TSDF. Contrary to the Anderton study of 1990 Census data, Been finds the percent poor in a community is negatively correlated and significant again suggesting that poor communities may repel waste facilities. They also find median household income to be positive and significant (Been and Gupta 1997). The Anderton study (1994) finds the percent poor and percent families on public assistance to both be positively and significantly correlated with TSDFs. Since both use census tracts and 1990 Census data,

[34] A similar result is found by Tom Boer et al. He claims that some areas are simply too poor for any economic activity yet others are wealthy enough to resist it. He concludes the communities that are at risk for a LULUs are working-class, minority neighborhoods in industrialized areas.

this difference may be due to Anderton's limiting the area of study to metropolitan regions with at least one TSDF thus biasing his results.

Been then tests the market dynamic theory – the idea that once a TSDF, or any local undesirable land use (LULU), is sited in a community, that community becomes less desirable thus driving housing values down. Those who remain in the community do so because they have limited choices due to their socio-economic status and those who enter the community tend to be less wealthy than those who chose to leave thus resulting in a neighborhood with lower incomes and, according to Been and Gupta, "higher percentages of those who face discrimination in the housing market – primarily racial and ethnic minorities" (1997).

The authors test this theory of market dynamics by regressing the 1990 demographic variables on the demographic characteristics from the census *prior to the siting* including a dummy for the presence or absence of a waste facility. Neither percent Blacks, percent Hispanics, nor household income in 1990 is significantly related to the presence of a facility in the 1970's or 80's; Been attributes this to the siting of waste facilities in Black communities prior to 1970. When she regressed the 1990 demographic variables on the presence of a facility in 1990, however, she found both Blacks and Hispanics as positive and significant predictors of a TSDF (Been and Gupta 1997). It is difficult to draw a general conclusion regarding Been's market dynamic theory since her results vary from decade to decade.

There is evidence that the areas around a TSDF were experiencing population growth in the 1970's and 1980's; tracts that host waste facilities have fewer vacant housing units and higher percentages of new housing construction indicating that the benefits of a TSDF, like job creation, may outweigh the costs (Been and Gupta 1997).

Two other studies find little evidence to support this market dynamics theory; one at the national level, the other is a study of Los Angeles County.[35] The researchers of the national study conclude that the changing racial and ethnic composition of communities hosting TSDFs is due to general trends in the population (Oakes et al. 1996). Whereas the L.A. County study does find that disproportionate minority populations may be the cause for siting a TSDF, the causality can not be reversed: the presence of a facility is not cause for minorities to move into the community. It is also worth noting that the L.A. County researchers find evidence that communities in ethnic transition are more susceptible to TSDF siting due to the deteriorating bonds that originally developed through race and ethnicity (Pastor et al. 2001).

4.3 Recent Empirical Evidence: Beyond Proximity to TSDFs

Although early environmental justice research has been effective at increasing awareness by both the EPA and members of congress, as Boerner and Lambert point out, the majority of the literature up to the mid-nineties measures a disparate impact using the proximity to waste facilities without accounting for actual elevated levels of risk. These studies imply a risk associated with living near a TSDF, yet the danger comes from actual exposure to these waste facilities, not just proximity to them. These early studies fail to address the claim that minority communities suffer adverse effects due to disproportionate levels of exposure to TSDFs (Boerner and Lambert 1995).

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[35] See Gauna et al (2003) for a comprehensive summary of the Oakes and Pastor studies.

In 1998, John Hird and Michael Reese take a different methodological approach than that of their predecessors. They use 29 indicators to measure the health of the environment including industrial air emissions, industrial water discharges, water quality, air quality, *and* proximity to hazardous waste sites in communities across the nation (1998).

Like Been, they too find income to be positively and significantly related to pollution levels; whereas the relationship between poverty and pollution is negative. Race proves to be a strong indicator of high pollution levels -- even when controlling for income, manufacturing activity, and population density -- as nonwhites and Hispanics are both exposed to disproportionately high levels of pollution. Using owner-occupied housing as a proxy for political mobilization, Hird and Reese find that high levels of owner-occupied housing are strongly and consistently related to lower levels of pollution. Not surprisingly, population density is a positive indicator of pollution levels (1998).

The authors conclude that minorities are exposed to disproportionate levels of pollution and the disparate impact is not only at the regional level, but a consistent trend throughout the nation. Even when controlling for various types of pollutants, income, urbanization, and manufacturing activity, pollution levels are disproportionately affecting minorities. There are, however, other important demographic variables contributing to the inequitable distribution of pollution like political mobilization, income, and population density – all of which have a strong relationship with pollution levels (Hird and Reese 1998).

An alternative to Hird and Reese's 29 indicators of environmental quality is the Toxic Release Inventory (TRI) compiled and maintained by the EPA since 1987[36]. Over 75,000 companies are required to report their emissions to the EPA by chemical, medium in which it is released, and amount released. Much of the recent environmental justice literature utilizes the TRI as a measurement of environmental quality. Polluting facilities listed on the TRI outnumber waste facilities by almost 40 to 1 (Ringquist 1997).

Evan Ringquist's 1997 study uses the five digit zip code as the unit of analysis reminiscent of the UCC study, but instead measures environmental quality with the TRI and accounts for three aspects of environmental quality that were not captured in previous studies: the distribution of TRI facilities, the density of TRI facilities, and the concentration of the emissions (1997).

Considering both the distribution and the density of TRI facilities, race is a significant predictor of the presence of a polluting facility; whereas, both median household income and poverty rates are negatively related to a facility's presence once again suggesting that facilities tend to be located in working class neighborhoods (Ringquist 1997).

For each zip code area, Ringquist weighted the amount of emissions from TRI facilities as a proxy for exposure to environmental risk in lieu of using proximity as a measure of exposure and finds that communities with large shares of African Americans and Hispanics suffer from significantly higher levels of TRI emissions. Ringquist concludes that racial disparities exist regarding the distribution and density of TRI

[36] See www.epa.gov/tri.

facilities as well as the concentration of TRI emissions. African American and Hispanic communities are exposed to greater environmental hazards than other communities. He also asserts that although other socio-economic variables are indicators of the location of a TRI facility, they are less reliable and consistent predictors than expected (1997).

A similar study using TRI as a measure of pollution, specifically emissions released into the air, and zip codes as community definitions finds results consistent with Ringquist's study. Even when accounting for other socio-economic characteristics such as level of education, levels of poverty, and renter occupied housing units, communities with high shares of African Americans are the greatest predictors of high pollution levels (Brooks and Sethi 1997).

Both of these studies account for pollution levels as they pertain to a specific area, but neither of them addresses the health effects of this pollution on the exposed communities. The Institute of Medicine's Committee on Environmental Justice addressed the issue of adverse health effects associated with disproportionate exposure to pollution after a review of the scientific literature. The committee concludes:

> There are identifiable communities of concern that experience a certain type of double jeopardy in the sense that they (1) experience higher levels of exposure to environmental stressors on terms of both frequency and magnitude and (2) are less able to deal with these hazards as a result of limited knowledge of exposures and disenfranchisement from the political process. Moreover, factors directly related to their socio-economic status, such as poor nutrition and stress, can make the people of these communities more susceptible to adverse health effects of these environmental hazards and less able to manage them by obtaining adequate health care (1999).

A couple of years later in 2001, Rachel Morello-Frosch and her research team go a step further than the TRI as a measure of environmental risk in order to capture the adverse health effects associated with greater exposure to toxins in the air. They use the hazardous air pollutants (HAPs) listed in the 1990 Clean Air Act Amendments in order to estimate lifetime cancer risks among communities in the Southern California Air Basin. Population risk indices (PRIs) were calculated to examine the relationship between race and cancer risk based on exposure to HAPs. The results reveal that the PRI was above average for all minorities with Hispanics experiencing the highest level for cancer risk (2001).

Like their predecessors, the authors control for other factors associated with pollution levels: income, population density, land use, and home ownership as a proxy for political mobilization and yet the results reveal racial disparities in cancer risk associated with exposure to toxic air pollutants. According to the study, the likelihood that a person of color will live in a high cancer risk community in Southern California is one in three; whereas, the same scenario for a White person is approximately one in seven (Morello-Frosch et al. 2001). It is worth noting here that the pollutants used in this study, although carcinogenic, are not necessarily the most dangerous; there are particulates not accounted for here that may be very potent (Banzhaf and Walsh 2004).

Professor Morello-Frosch's research, in conjunction with other studies using the TRI or a similar measure of pollution, provides a response to methodological criticisms posited by Boerner and Lambert; they reveal disproportionate exposure to pollution and its effects across communities. But few recent studies using new methodologies have returned to the question posited by Been of which came first – polluting facilities or minorities? Since many of the policies on environmental justice rest on the claim that polluting and waste facilities are disproportionately *sited* in minority communities, contrary evidence could have an impact on policies intended to reduce inequitable distribution.

Cameron and Graham (2004) evaluate community composition in areas in close proximity to 6 Superfund sites. They use demographic data at the Census block level for a more granular analysis than previous studies and they also weight the different risk levels according to each community's distance from the Superfund site. Their analysis reveals heterogeneous shifts in the population across these communities; however, since the scope of the study is limited to only these 6 sites, it remains difficult to generalize these results.

The same year, a study by Banzhaf and Walsh reexamines the question hypothesized by Been and does so with significant advances in methodology. Banzhaf and Walsh look to Charles Tiebout for theoretical motivation for their empirical work. Tiebout claimed that individual households will sort themselves into communities based on their demand for goods and services (1956). In this case, environmental quality is considered a normal good; therefore, if a polluting facility enters a community and environmental quality declines, as do housing values, low income families will move in and higher income families, who demand higher levels of environmental quality, will move out – a concept very similar to Been's market dynamics theory (Banzhaf et al. 2004). Been and Gupta attribute this process of "sorting" not only to income but also to racial discrimination in the housing market, but Banzhaf and Walsh claim that since "minority households have lower average incomes than White households, this differential sorting could lead to the observed correlations between minority status and environmental quality”(2004 pp 1).

In the spirit of Tiebout and, more recently, Been and Gupta, the Walsh study examines the demographic changes in the population as they relate to the changes in exposure to TRI emissions which are then weighted by toxicity levels. Adding depth to their study, the authors also control not only the changes in pollution levels from existing facilities, but also the impact of entering and exiting facilities. Also they include lagged demographic responses to pollution to avoid endogeneity problems – if facilities are indeed sited according to race, then the estimates explaining the relationship between changes in pollution levels and changes in racial composition could be biased. Lagging the demographic response will make them exogenous. They also control for unobserved spatial amenities with zip code and school district fixed effects (Banzhaf and Walsh 2004).

Since results are often highly sensitive to community definitions often eliciting criticism and skepticism, Banzhaf and Walsh abandon the traditional community definitions like zip code boundaries and census tracts. Instead they define their own “communities” using a set of circles, one-mile then half-mile in diameter, evenly distributed across California thus all “communities” are the exact same size. Then they map block level census data to each circle-community and eliminate circle-communities that are not denoted as urban as of 1990 (2004).

Banzhaf and Walsh use GIS[37] software to calculate the appropriate amounts of TRI emissions to be assigned to each community. Also, instead of simply measuring pollution by pounds of emission released, they measure it by toxicity using the EPA's Risk Screen Environmental Indicators model so that more dangerous pollutants are assigned a heavier "weight" (2004).

Yet another advance in their methodology is their application of pollution to each community. They match facilities to their communities using the latitude and longitude coordinates, which are also provided by the EPA. Then they construct quarter mile and half mile diameter "buffers" around each coordinate and assign the appropriate pollution levels based on what portion of each community lays within the buffered region (2004).

First the authors estimate a probit and tobit to test the correlation between minorities and the presence of TRI facilities. The dependent variable for the tobit is the 1990 hazard-weighted TRI exposures and the probit is simply the presence or absence of a TRI facility. They use share Black, share Hispanic, share Asian, population density, kilometers to coast, degrees latitude, and school district fixed effects as the regressors to varying degrees in three different models. For both the probit and the tobit, all three models revealed a positive and significant relationship between the share of minorities and TRI exposure (2004).

Next they use OLS to regress each race on the presence and amount of TRI exposure, population density, and school district fixed effects to reverse the causality of the relationship. Hispanics appear to be significantly associated with greater emissions

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[37] Banzhaf and Walsh use the ARCVIEW GIS software package to attach both the TRI emissions and U.S. Census block data to their circle-communities.

levels; Whites and Asian/Pacific Islanders are negatively related to TRI facilities and emissions levels (2004).

After the authors establish these relationships, they then examine the migration effects due to changes in environmental quality. This time they regress the change of the share of *each* racial group in the community on a set of exposure variables: TRI exposure measured as a three year lagged average, an indicator for when a community changes from not exposed to exposed and one for when a community moves from exposed to not exposed, change in emission levels, and to capture lagged reactions to pollution they use 1990 emissions levels and an indicator for the presence of a facility in 1990. They estimate four models for each racial group, beginning with the exposure variables, then they add demographic controls and then school district and zip code fixed effects (2004).

They find that metropolitan areas are becoming less African American and Asian and increasingly White and Hispanic, and areas with high concentrations of Whites are becoming less White over time. When accounting for pollution levels, the results show that baseline exposure and new TRI exposure – shifting from not exposed to exposed – causes the circle-communities to become 2 to 3 percent less White with Hispanics picking up the slack. These results are statistically significant and are similar for both the one mile circle-communities and half mile circle-communities[38] (2004).

Banzhaf and Walsh assert that these results provide strong evidence of a "composition effect" resulting from changes in environmental quality. Interestingly,

[38] Since it is a working paper, at this time, Banzhaf and Walsh's paper does not provide results for each of the variables they used in the regression analysis. For the composition effects model, they only provide results for the exposure variables.

most of this effect is coming from the indicator variable signaling the entrance of a TRI facility into a community, not the continuous measure of emissions levels in a community. This may be due to the greater impact of a facility entering an area that previously was not exposed; whereas, the continuous measure of emissions may signal a marginal change thus eliciting a small or insignificant effect on the community. This effect may be why Vicki Been did not find any evidence of a migration response to changes in environmental quality. She included an indicator for the presence or absence of a facility, but not for the entrance of a facility into an area that was previously "free" from TRI emissions (Banzhaf and Walsh 2004).

Overall, much of the empirical research provides substantial support for the EJ claim that minorities suffer a disproportionate risk to environmental hazards. Measuring the risk via proximity to TSDF sites, actual exposure levels, and adverse health effects have all provided supporting evidence of the claim. Evidence supporting the theory of market dynamics, however, is mixed. Been and Gupta (1997) find some evidence in 1990, but none in 1970 or 1980 thus making it difficult to draw a clear, qualitative conclusion. Oakes (1996) and Pastor et al (2001) find no evidence of market forces attracting minorities to pollution; whereas, Banzhaf and Walsh (2004) do find that exposed communities become less White over time.

The Maricopa County study that follows will contribute to the current literature in two ways. First it will provide additional evidence on disproportionate risk. Previous studies suggest that the Hispanic population is particularly at risk so this research will provide insight into the relationship between Latino communities and pollution.

Secondly, it will also supply additional evidence on the market dynamics or "Tiebout Sorting" theory by examining the effects of increased levels of TRI emissions versus the introduction of new facilities into a community and its effect on the shift in the community composition. The shifts are examined defining the block group as the community boundary, as opposed to the census tract, which is criticized for its potential to mask changes within its boundaries, and the one mile circle communities which limits Census data to the block level which is sparse.

Chapter 5 -The Arizona Experience

Chapters two and three demonstrate that a successful environmental justice legal argument provides evidence that a minority or low income community is suffering from a disproportionate environmental risk. In the spirit of this legal requirement and the recent literature, several equations are estimated in this chapter to examine the EJ experience in Arizona which aims to determine *(1)* if polluting facilities are sited in areas with high concentrations of minorities thus creating a disparate impact, *(2)* if the causality can be reversed and these polluting facilities explain the high concentrations of minority residents in exposed communities, and *(3)* if this relationship does exist, is the minority population actually migrating to these polluted areas? The following sections in this chapter will provide relevant background on the geographic study area, establish the econometric framework for the analysis along with a description of the data used in the models, and the final section will conclude with a summary of the results and their implications.

5.1 Background on Maricopa County, Arizona

The NRDC study notes that 66 percent of Hispanics live in regions that fail to meet federal air quality standards including Phoenix, Chicago, New York, Houston, California's Central Valley, and the U.S.–Mexico border region. The geographic scope of this study is Maricopa County, Arizona, which is home to the major metropolitan areas of Phoenix, Mesa, and Tempe as well as the Gila River and Salt River Pima-Maricopa Indian Communities and covers and area of over nine-thousand square miles.

Phoenix is home to some of the most congested roads in the U.S.[39] and Maricopa County violates air quality standards of carbon dioxide, ozone, and particulate matter. The community of South Phoenix is 60 percent Hispanic and it has the highest asthma rate in Maricopa County. It is estimated that 25 percent of the children in the neighborhood's Roosevelt Elementary School District suffer from asthma (Quirindongo et al 2004).

In the year 2000, Maricopa County was home to 3,072,149 residents – a whopping 44.8 percent increase from 1990 – of which 3.6 percent were African American, 1.8 percent were Native American or Alaska Native, and 24.9 percent, up about 10 percent from 1990, were Hispanic, which was the only minority to significantly increase its share in the population over the decade. It is worth noting here that the birth rate among Hispanics is about 3 percent higher than the national average and about 4 percent higher than Whites[40]. So although some of the 10 percent increase in the share of Hispanics can be attributed to a higher than average birth rate, it is not the only driver for their increased share in the population. Tables 5.1 and 5.2 display the variable definitions and descriptive statistics, respectively.

5.2 Establishing a Relationship Between Minorities and Pollution

The relationship between pollution and minorities is a complex one reminiscent of the circular "chicken and egg" argument. While the question of "which came first?" is

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[39] Phoenix was ranked 14th in the U.S. in hours spent in traffic congestion per year. See D. Schrank and T. Lomax, Texas Transportation Institute, "The 2003 Annual Urban Mobility Report" available at http://mobility.tamu.edu/ums/. Last visited 5/2005

[40] See the National Vital Statistics Reports, "Estimated Pregnancy Rates for the United States, 1990 to 2000: An Update". Vol 52, Number 23. www.cdc.gov/nhcs/pressroom/04facts/pregestimates.htm. Last accessed 05/2005.

inevitable, it has also been proven rather difficult to answer. The next few sections attempt to break this relationship down into a pattern that is comprehensible. First, the facility location decision is estimated using a probit model to determine if there is a disproportionate number of facilities sited in or near minority communities. Next, the causality is reversed to establish if the presence of these facilities explain the share of minorities in the surrounding neighborhoods. Since these models are static, they do not explain whether or not the siting decision by a polluter was discriminatory or if the household decision to sort into a certain community is a subsequent result of the pollution, but they do establish an ongoing interdependent relationship between pollution and minorities. A third simultaneous model is then estimated to better account for this possibility of an interdependent relationship. Then the shift in the population is estimated to determine if the minority population in Maricopa County actually migrated toward these TRI sources from 1990 to 2000.

5.2.1 Modeling the Siting Decision

A probit equation is estimated to explain a facility's presence in a community. The presence or absence of a facility is indicated with a one and zero respectively and is regressed on the share of minorities in the community (SHMIN) as well as income levels (INCOME, RENT, OWN), educational attainment levels (NO_DIPLOMA, DIPLOMA, DEGREE), and variables measuring the population density in the community (DENSITY) and occupation which is a proxy to determine if residents work in the same community where they live (MANUFCTG, COMMUTE).

A generalized formulation of the probit proposed by Harvey (1976) is used which includes a correction for heteroscedasticity. This version of the probit accounts for a nonconstant variance by specifying the variables suspected to cause heteroscedasticity, called *z*, so that the variance of the error term looks like $Var[\varepsilon \mid \mathrm{x}, z] = [\exp(z'\gamma)]^2$ (Greene 2003 pp. 680). So when $\gamma = 0$ there is no heteroscedasticity and the variance of the error is equal to one thus also capturing the standard probit.

In an attempt to mitigate the effects of endogeneity, the dependent variable, EXPOSURE, measures the presence or absence of exposure from 1995 and the explanatory variables are from 1990.

5.2.2 Reversing the Causality

After modeling the polluters' siting decision, the causality is reversed and this time the share of minorities (SHMIN) in each community is regressed on the presence of pollution (EXPOSURE) and the emission levels (EMISSIONS), while controlling for housing values in the community (HOUSEVALUE, RENT, OWN), and occupation variables (MANUFCTG, COMMUTE). Instead of a binary decision, a continuous measure of the share a community's minority population is the dependent variable thus a linear regression model is appropriate[41].

Since the data in this study are cross-sectional and the scale of the dependent variable varies across observations, an OLS model may not be sufficient as the classical

[41] Usually when the dependent variable is bound between 0 and 1, as it is here, a log odds ratio model would be best. However, since in this sample there are communities that have both 0 minorities and 100 percent minority populations, the log odds ratio model is undefined. Since it is the marginal effects of this model that are of interest, not the predictions, a linear model is used.

assumption of constant error terms could be violated[42]. The generalized linear regression model offers a correction for nonconstant variance with the addition of a positive definite matrix, □, so that the model looks like

$$\begin{aligned} y &= X\beta + \varepsilon, \\ E[\varepsilon \mid X] &= 0, \\ E[\varepsilon\varepsilon' \mid X] &= \sigma^2\Omega = \Sigma, \end{aligned} \tag{1}$$

(Greene 2003 pp. 191) where, if the error terms are indeed constant, $\Omega = I$ and so the homoscedastic case is nested in the generalized model thus adding to its desirability. Since □ is often unknown, as it is in this case, it must be estimated. To do so the Feasible Generalized Least Squares (FGLS) model is utilized. Assuming the transformed regressors are "well behaved" (Greene 2003 pp210) and $\hat{\Omega}$ is estimated using a consistent estimator, the FGLS model will have the same asymptotic properties as GLS thus it will not only be consistent but efficient as well. Like the probit model, the FGLS model also estimates the lagged effects using SAS; however, this time the dependent variable, SHMIN, is the minority share from 2000 and the independent variables are pollution levels from 1995.

5.3 Simultaneous Estimation

Estimating these equations separately provides a basis for the framework of the empirical piece of the environmental justice argument, but since the hypothesis in this case is not only to show that a relationship between minorities and pollution exists, but that the relationship is interdependent, a system of equations which includes both of these

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[42] For 1990 and 2000 the Bruesch-Pagan/Godfrey test statistics are 274.47 and 190.17 respectively. The critical value for $\chi^2_{.05}(3)$ is 7.815; therefore, the null of homoscedasticity is rejected.

models simultaneously will provide more reliable estimates. Using least squares to estimate the parameters in the equations separately could result in inconsistent estimates because the variables on the right-hand side are endogeneous and correlated with the disturbance terms (Greene 2003). The use of lagged variables in the previous two models does mitigate the effect of endogeneity; however, the joint model better addresses the endogeneity problem while also accounting for time-wise heteroscedasticity.

The simultaneous model used for explaining the siting decision and reverse causality is given by:

$$(2)\quad EXPOSURE_{it}^{*} = b_0 + b_{00}\cdot DUM2000_{it} + b_1\cdot MANUFCTG_{it} + b_2\cdot INCOME_{it} + b_3\cdot RENT_{it} + \gamma_1\cdot SHMIN_{it} + u_{1it},$$

where

$$EXPOSURE_{it} = \begin{cases} 0 & \text{if } EXPOSURE_{it}^{*} \le 0 \\ 1 & \text{if } EXPOSURE_{it}^{*} > 0 \end{cases}$$

and

(3)

$$SHMIN_{it} = c_0 + c_{00}\cdot DUM2000_{it} + c_1\cdot SHOWN_{it} + c_2\cdot POPDEN_{it} + \gamma_2\cdot EXPOSURE_{it}^{*} + u_{2it},$$

where, $b_0, b_{00}, b_1, b_2, b_3, c_0, c_{00}, c_1, c_2, \gamma_1, \gamma_2$ are parameters to be estimated, u_{1it} and u_{2it} are disturbance terms and *DUM2000* is an indicator for year 2000 and other variables are as given in Table 5. The structural model given in equations (2) and (3) is simultaneous with unobservable endogenous variable on the right hand side of (2). An estimation procedure should account for this simultaneity and possible correlation between u_1 and u_2 to obtain consistent and efficient parameter estimates[43].

Although an improvement to estimating the models separately, estimating simultaneous equations is not without its challenges. Oftentimes, simultaneous equation models are subject to identification problems and determinates of endogeneity can be subtle and vague. However, in this instance, it provides the most reliable parameter estimates since a system of equations more closely models the complex interdependent relationship examined in this work.

5.3 Estimating the Migratory Effects of Pollution

A fourth model is estimated to measure the shifts in population from 1990 to 2000 in an attempt to answer the question posed by Been and Gupta (1997) and also explored by Banzhaf and Walsh (2004): are racial and ethnic minorities migrating toward the pollution? In an attempt to model these changes in community composition, again an FGLS model[44] is estimated in SAS this time regressing the *change* in the minority population from 1990 to 2000 (DMIN) on the *change* in pollution from 1990 to 1995 (DEMISSIONS, ENTRANCE, EXIT, EXPOSURE90) as well as the *change* in housing values (DHV, DRENT), population density (DDENSITY) and employment variables (DMANFG, DCOMMUTE).

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[43] Appendix 4 provides the interested reader with details of this estimation procedure. Also see Greene pages 378 – 382.

[44] Again the Breusch-Pagan/Godfrey LM test is conducted; the test statistic is 16.73 and the critical value for $\chi^2_{.05}(3)$ is 7.815; therefore, reject the null of homoscedasticity and proceed with FGLS as an OLS model would be misspecified.

Banzhaf and Walsh (2004) note that if polluters are indeed making discriminatory siting decisions, measuring a shift in the minority population that is spurred by pollution may cause endogeneity problems; therefore, the pollution variables for 2000 (DEMISSIONS, ENTRANCE, EXIT) are lagged to 1995 levels. Although the lagging will not completely eliminate the problems of endogeneity, it does mitigate the effects of endogeneity on the parameter estimates.

5.4 The Data

Although environmental justice concerns both racial and ethnic minorities as well as low income communities, race is the focus of this study since it is highly correlated with poverty and is consistent with much of the EJ literature. Also, since Hispanics comprise almost all of the minority population in Maricopa County where Native Americans and African Americans account for only two and three percent respectively, they are grouped together to represent the overall minority share. Asians are omitted from the minority category since their socioeconomic characteristics more closely resemble White's.

Data for the empirical work that follows comes from two main sources: the U.S. Census from 1990 and 2000 at the block group level as a demographic and socioeconomic measure and the Toxic Release Inventory (TRI) compiled and maintained for the public by the U.S. EPA as a measure of environmental quality. The TRI data is attached to "communities" which are defined using block group boundaries from the U.S. Census.

5.4.1 Community Definitions

Environmental justice studies show that results relating pollution to poor and minority communities are often sensitive to community definitions; these definitions have ranged from zip codes (UCC 1987, Goldman and Fitton 1994) to census tracts (Anderton et al. 1994, Been 1997) and, most recently, to constructed "circle-communities" (Banzhaf and Walsh 2004). This study uses the block group to define community boundaries; it provides a smaller unit and less aggregated measure than the census tract which may mask demographic shifts within the tract. Analysis at the block group level provides greater resolution than at the tract level without sacrificing relevant information publicly provided by the U.S. Census. One problem Banzhaf and Walsh (2004) face is the lack of information publicly available at the block level, which is the level of census data they use to attach demographics to their "circle-communities".

Much like the census tract boundaries, however, one drawback of using the block group as a community definition is its variation in size. For example in Maricopa County in 2000, the block groups range from about .08 square miles to 1,675 square miles thus making it difficult to account for the "large degree of heterogeneity when estimating migration models" (Banzhaf and Walsh 2004 p.10). In 2000, the population ranges from 0 to 14,658 people per block group with a mean of 1,454.

Another problem with using block groups is the shifting of block group boundaries from Decennial Census to Decennial Census thus making it difficult to compare across time periods. To solve the problem, Geolytic's developed their

Neighborhood Change Database[45] (NCDB) which aggregates the 1990 U.S. Census block group and census tract boundaries to the 2000 levels. Using Geolytic's NCDB package, there are a total of 2,113 block group communities for both 1990 and 2000 in Maricopa County after the boundary adjustment. Eight block groups were eliminated from the sample which had no residents from 1990 to 2000 leaving a total of 2105 block group communities.

Figures 1 and 2 provide maps of Maricopa County including the block group boundaries aggregated to the 2000 levels. The maps are overlaid with the mean percent of Hispanics per each block group for 1990 (Figure 1) and 2000 (Figure 2) and also with the top 25 polluting TRI facilities for each time period. It is clear from the maps that communities with high percentages of Hispanics also tend to be in close proximity to a TRI facility. Interestingly, according to the maps, it appears as though the areas with TRI facilities become more Hispanic from 1990 to 2000.

Among only the "exposed" communities the share of Hispanics increased from 1990 to 2000 by about 15 percent, a rate 5 percent higher than the rest of the county. In 2000, the mean income among exposed communities was $42,029, 13.7 percent below the county mean, and the share of people living below the poverty level was 5% above the county average.

5.4.2 Toxic Release Inventory

Boerner and Lambert (1995) posit that early studies using TSDF sites as a measure of risk fail to measure *actual* exposure to toxins; instead they measure the *threat*

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[45] For more information on NCDB see http://www.geolytics.com.

of exposure. In the spirit of recent research, as an alternative to TSDF sites and a more accurate measure of pollution exposure as it relates to health risks, facilities reported on the EPA's Toxic Release Inventory are used in this study as a measure of environmental quality.

The TRI was developed by the EPA in 1987, under the umbrella of the Emergency Planning and Community Right-to-Know Act of 1986 (EPCRA)[46]. The EPCRA requires facilities releasing significant amounts of various chemicals each year to report to the EPA who began to maintain a database on these releases that is available to the public – the TRI. Since the TRI is not a static program, new chemicals and industries have been added to the list of reporting requirements since its inception in 1987. For the empirical work that follows, only the 1988 required core chemicals were used as a measure of pollution to maintain consistency in reported chemicals from 1990 to 2000.

In order to measure a facility's impact on society more accurately, emissions have been weighted by toxicity using the EPA's Risk-Screening Environmental Indicators[47] (RSEI) model which works in conjunction with the TRI and is also used in recent research by Banzhaf and Walsh (2004). The RSEI assigns a "hazard score" to a facility's emissions by accounting for not only the *amounts* of chemicals released, but also for the *environmental concentrations* resulting from releases, *doses* that people receive from those concentrations, the *relative chronic toxicity* of those doses and the *number of those affected*. There are 125 TRI facilities in Maricopa County in 1990, 99 facilities in 1995, and there are 122 facilities in 2000.

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[46] See http://www.epa.gov/tri/tri_program_fact_sheet.htm.

[47] Information on the RSEI model can be found at http://www.epa.gov/oppt/rsei/.

5.4.3 Assigning TRI Exposure and Emissions Levels

In order to measure exposure not only of the communities hosting a TRI facility, but of the surrounding communities which are also experiencing an externality, a one mile radius is constructed around each TRI facility. Banzhaf and Walsh (2004) similarly use a one mile then half mile radius "buffer" around facilities and found no significant difference between the two. Using a larger radius may be problematic since it would assign the same emission levels to a community hosting a facility or adjacent to the facility as it would to a community that is, for example, 2 miles away. With additional time and resources, a more in depth analysis could be preformed with a larger radius using a gradient function to assign diminishing levels of pollution to a community as it gets farther from a TRI facility or using weather patterns to determine which communities are affected most by different types of pollution.

To construct the buffers around each facility, first, using Geolytic's software, the latitude and longitude coordinates were entered for a facility[48]. Then a one mile radius is drawn around that point source of pollution. This is done one facility at a time for 1990, 1995[49], and then again for 2000. Any block group that is captured in that radius is considered "exposed" and assigned a "1" for the exposed indicator variable even if the block group community is exposed multiple times.

Next, emissions levels are assigned to each community. In order to "weight" the emissions for each community so that communities which are only exposed by a fraction

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[48] The longitude and latitude coordinates are provided for each facility on the TRI and they have been cross-checked and corrected for the RSEI model.

[49] Exposure at the 1995 level was calculated to capture a lagged effect when examining the population change from 1990 to 2000.

are assigned fewer emissions than one that is entirely exposed, a variation of the above method is used. This time instead of using the block *groups* that are captured in the one mile radius, the smaller units of blocks are used. Since blocks are typically much smaller than block groups, when the radius is constructed around the facility many blocks are captured in that radius, opposed to only three or four block groups. Each block can then be matched to its block group. Exposure at the block group level is then calculated by summing the total square kilometers for each block exposed in the group and dividing it by the sum of the area of all exposed blocks within the radius of the facility. That fraction is then multiplied by the hazard score for that facility. This is repeated for each facility and for each time period; hazard scores are summed for block groups exposed to multiple sources. So the equation looks like

$$BlockGroupEmissions_m = \sum_{i=1}^{n} \left\{ \frac{\sum_{j=1}^{n} AreaBlocksExposed}{\sum_{t=1}^{n} AreaAllBlocksExposed} \times HazardScore \right\}, \quad (4)$$

where i = facility, j = blocks within same block group m, and t = total blocks exposed to facility i.

5.5 Results

1) The Siting Decision. Results from the probit model, shown on Table 3, reveal a positive and highly significant relationship between TRI exposure and minorities, which is consistent with much of the EJ literature. There is also a positive and significant relationship at the 5 percent level between those employed in the manufacturing industry and pollution, indicating that there may be benefits by way of employment in these communities that outweigh the risk for some especially since a short commute to work is also significant.

As expected, income has a negative relationship with a facility's presence, but it fails to be a statistically significant predictor of TRI pollution, although home ownership rates are also negative yet significant to the one percent level. Also there seems to be a nonlinear relationship between rent and the likelihood of a TRI since rent is positive but its squared term is negative; the squared term, however, is not significant. This nonlinear relationship is consistent with Been and Gupta's (1997) findings that TSDF's were often sited in working class neighborhoods and were actually repelled by very poor areas that lack the infrastructure to support such a facility. Initially, as rents increase, so does the probability of TRI exposure until the median rents are too high in a community, and again they begin to repel facilities.

Another interesting and unexpected result comes from the educational attainment variables. A 5.5 percent increase in residents with college degrees increases the probability of exposure by 10 percent; whereas, the other educational attainment variables proved to be insignificant predictors of pollution.

Since there are many considerations taken into account when choosing a facility and they are not all represented here, it is not necessarily appropriate to conclude that these siting decisions were made in a discriminatory fashion, but the model does reveal that there is a relationship between high concentrations of minority residents and TRI pollution even when controlling for income, occupation, and education.

2) *Reversing the Causality.* The results, shown on Table 4, for the FGLS model reveal a relatively high adjusted R^2 of .446 for cross sectional data. The R^2 could be improved with the addition of variables capturing other attributes of a community that make it attractive to racial and ethnic minorities like proximity to bilingual schools and churches, or to public transportation. A survey of people in the region would best capture other reasons for choosing one community over another like sentimental attachment, family connections, or common language among the community.

Results from the FGLS model reveal that the presence of a facility is a positive and significant predictor at the 5 percent level for the share of minorities in a community – the presence of a TRI facility increases the minority share by 9.6 percent; interestingly the level of pollutants released is not significant indicating that the mere *presence* of a facility, regardless of the hazard level or amount it is emitting, is a predictor of a high share minorities in a community. Banzhaf and Walsh (2004) find similar results in their California study claiming that the larger impacts are those caused by an exposure dummy; whereas, the magnitude of the continuous emissions variable is small and a marginal change is insignificant.

Another result worth noting here is that the share of people working in their communities or neighboring communities (COMMUTE) is a significant predictor of increased minority share just as it indicates TRI siting decisions in the probit model. The share of those in manufacturing jobs is also positive and significant, which provides support that those jobs are close to home for minority residents. These results provide further evidence for conclusions posited by Been and Gupta (1997) who claim that the employment benefits of a TSDF may outweigh the costs.

Expectedly, housing values, rent, and share of homeowners in a neighborhood (HOUSEVALUE, RENT, OWN) are all negative and significant indicators of minority share. Since the lagged variables do not eliminate problems with endogeneity, it is inappropriate to draw a solid conclusion regarding the household decision among minorities to move toward the pollution; the FGLS model does, however, indicate there is indeed a positive and significant relationship between the two.

3) Simultaneous Estimation Results. The results from the joint model, shown in Table 5, do provide strong evidence of an interdependent relationship between the minority community and TRI pollution as many of the results from the previous two models are reinforced. Firstly, exposure is a strong, positive predictor of minority share at the 99 percent level, and minority share is also a positive, significant predictor of exposure. Homeownership and rent maintain their negative relationship with minority share as does income with exposure – all at the 5 percent level of significance. High shares of manufacturing jobs continue to be positively correlated with exposure again at the 5 percent level of significance and minorities maintain a positive relationship with population density. These results reveal that the decision to build a plant and the decision to remain in a particular exposed community are not isolated but an interdependent system of preferences that influence each other.

4) The Migration Effects. Table 6 presents results from the migration equation. The results reveal that when a facility enters a community in 1995 that was previously not exposed, the share of minorities will subsequently increase by nearly 3 percent in 2000. The opposite is true if a community switches from exposed to not exposed -- when a TRI facility exits a community in 1995, the share of minorities in that area decreases over 3 percent by the year 2000.

At first glance, it is counterintuitive that when the level of emissions released decreases marginally, the minority share increases with statistical significance. However, although the emissions are decreasing, it is the presence of the facility itself that causes the minority share to increase overall. So facilities may be emitting less for a variety of reasons, but, as shown in the other models, the minority share will increase due to the mere presence of a TRI facility perhaps due to benefits from lower housing values and rents, which are also negative and significant indicators of a change in minority share. Benefits that emerge from employment, however, are insignificant.

Recall from the first two models that a high percentage of manufacturing jobs high percentages of workers with a short commute are significantly and positively correlated with both TRI facilities and high concentrations of minorities; whereas, when modeling the shift in community composition, neither are significant thus making it difficult to conclude that there are employment benefits driving the migration of minorities to exposed areas.

5.6 Conclusions of Empirical Research

Two conclusions emerge from this empirical work. First, TRI facilities in Maricopa County are disproportionately located in areas with high minority concentrations; this is the typical environmental justice finding. Second, the causation for this relationship goes both ways as minorities also tend to sort themselves into exposed communities.

Tiebout (1956) posits that households will choose a community based on their demand for public goods; for many low income and minority families, low housing costs take precedence over environmental quality. As mentioned previously, there may be many public goods such as schools, churches, or proximity to public transportation, for which there is greater demand than environmental quality for low income and minority households. Since this portion of the population is a heterogeneous group, the demand for these goods varies and for some it leads them to heavily polluted areas. However, on the basis of this work, it remains unclear as to whether or not people in the exposed communities are benefiting specifically from employment in their neighborhoods. The following chapter will discuss the policy implications of this research and examine notions of fairness as they relate to EJ issues.

Chapter Six – Notions of Fairness and Environmental Justice

Empirical evidence presented in this work, as well as several others of varying scope, reveals that minorities suffer from disproportionate exposure to hazardous pollution. The new challenge of EJ advocates is deciding how best to implement these findings into an effective policy that preempts the lengthy and costly administrative complaint process discussed in chapter three, yet accounts for the ebb and flow of the interdependent relationship between minorities and pollution.

One key finding in this paper is that the minority population is not a homogenous group - people within the group have different preferences as they relate to environmental risk avoidance. The empirical test of the Tiebout Hypothesis documents that there are three types of residents: *(1)* people who remain in the area despite additional facility sitings due either to indifference to incremental risk or prohibitive relocation costs, *(2)* people who migrate out of the region, and *(3)* people who migrate into the region due to an increase in economic opportunity or to access better public services. In the context of siting new plants, determining what is conventionally considered "fair" can not be clearly defined since each group has different preferences; therefore, denying a permit may benefit some residents while harming others.

6.1 Notions of Fairness

As a result of this heterogeneity, evaluating the impact of siting new facilities can not be based on conventional notions of fairness. Yet Robert Bullard and many EJ activists promote conventional ideas of fairness claiming that clean air is not a privilege but an intrinsic right, and Bullard further posits that a federal "fair environmental protection act" would secure that right for all Americans (1994).

Achieving this egalitarian ideal, however, results in inefficient treatment of environmental risk. Albert Nichols criticizes Bullard claiming that failing to prioritize environmental risk only exacerbates existing inequities and prioritizing such hazards according to risk would eliminate the largest and riskiest pollution first thus making environmental quality better for minorities and low income families in the affected areas (1994). However, even if there is only *one* source of environmental risk in the region and therefore no need to prioritize, Bullard's approach will *still* result in inefficiency due to the heterogeneity of the affected group. As chapter five established, minority communities have various demands regarding environmental quality; a policy like the federal "fair environmental protection act" assumes everyone in the community prefers cleaner air whereas some actually prefer more affordable housing in lieu of a cleaner environment. As a result of this finding, the application of a policy based on fairness would be inefficient.

A similar notion of fairness is promoted by Gerrard through his definition of environmental justice where he posits that "minority and low-income individuals, communities, and populations should not be disproportionately exposed to environmental hazards, and that they should share fully in making the decisions that affect their environment" (1999). This definition contradicts the results in the Arizona case which reveals that disproportionate risk may actually be efficient and the outcome even voluntarily selected by residents due to the fact that the minority and low-income individuals do not have the same demand for environmental quality.

These notions of fairness share a common failing; namely, that they are based on a *physical* conception of equity that is *not* tied to the individual well-being of residents which is determined by individual preferences. Conversely, welfare economic analysis is dependent on individuals' well-being as well as the distribution of the factors that satisfy individuals' preferences that promote their well-being (Kaplow and Shavell 2002). Along the same vein as Nichols' criticism of Bullard, economists Kaplow and Shavell argue that promoting analyses based on fairness may actually reduce the well-being of individuals and they hypothesize that welfare economic analysis should be employed exclusively in policy-making (2002). This welfare economic approach to policy incorporates the evidence of heterogeneity in the Arizona case and has played a role in decision-making in some states in the U.S.

6.2 Policy Implications

There are two chief solutions proposed to dealing with this heterogeneity. One is through community involvement in siting decisions. The other is via compensated siting programs. Community involvement in the decision making process, if an agreement is reached, may lower the probability that an administrative complaint will be filed in the future thus freeing up the EPA's resources and achieving a potential pareto improvement – a situation making some people better-off without making anyone else worse-off. Compensation for siting decisions goes a step further: community members who suffer the greatest risk from the proposed facility may be compensated thus achieving an actual pareto improvement – this is a very strong ethical result. This is, of course, assuming successful negotiations, which, at times, is a fairly strong assumption as negotiations can be costly and complex.

. The economic rationale behind these two chief solutions finds its roots in the Coase Theorem. In his 1960 article, Ronald Coase claimed that negotiation, regardless of conventional public policy, will naturally lead to pareto optimality (1960). A situation is considered pareto optimal when there exists no possibility to change that situation in order to make someone better-off without making someone else worse-off. He contends that potential pareto improvements can be reached through negotiation and, furthermore, that an actual pareto improvement can be achieved when negotiation is combined with compensation (Coase 1960).

Been (1994) cites three major justifications for compensation. The first is that if the benefits of a LULU to a community outweigh the costs, then community members would have almost no reason to deny the permit. Second, compensation programs provide for some level of distributive equity in situations where one community is bearing the risk for the benefit of a much larger region. And finally, the cost of compensating entire neighborhoods - whether through compensation for lost property values or mitigating risk by increasing the buffer zones - would be internalized by the firm therefore leading to more efficient siting decisions.

Been (1994) also notes that some states have implemented policies based on this theory of compensating the host community and she highlights two examples[50]. The first is the Massachusetts Hazardous Waste Facility Siting Act of 1980 which requires the plan of a hazardous waste facility be presented to the host community and its surrounding communities; construction will commence when the community representatives accept the agreement. Since its inception, six developers have attempted to construct hazardous waste facilities and not one has been approved.

Wisconsin has experienced greater success with a similar policy. In Wisconsin, once a permit for a facility has been requested, the community has 60 days to elect to participate in the process. If the community chooses not to do so, it no longer has the right to make any additional local requirements on the developer. On the other hand, if the community enters into negotiations, it agrees to arbitrate if an agreement can not be reached otherwise. This statute has proven to be much more successful than the Massachusetts Act. Since 1993, agreements have been reached in the development of five hazardous waste sites and forty-one solid waste sites with compensation ranging from free waste disposal services to property value guarantees (Been 1994).

Although compensation programs like these may not be the cure-all that EJ advocates are hoping for, they allow for inclusion in a process that once left minorities disengaged and they reveal the concerns of the community to the developer which may provide insight into design and maintenance of future facilities. Community involvement

[50] Although there is no formal environmental justice policy, the state of Arizona requires the Arizona Department of Environmental Quality to provide notice of major permit applications in environmental justice regions that may be impacted by the permitting decision.

in decision-making may be the most efficient approach to environmental justice issues. Negotiation allows for a potential pareto improvement, and compensation may even achieve an actual pareto improvement thus making the community better off. Once the negotiation process can be fine tuned and implemented into policy, it may prove to be an efficient solution to a chronic dilemma among low-income and minority communities.

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Table 1: Variable Definitions

DENSITY	Total population for each block group divided by the total square miles for each block group
SHMIN	Share of each minority (African American, Native American, and Hispanic) is summed for each block group for 1990 and 2000.
INCOME	Median household income for each block group
POVERTY	Percent of people living below the poverty level in a block group
OWN	Percent owning their homes out of total occupied housing units
RENT	Median rent paid for renter occupied housing in a block group
HV	Median self-reported house value for each community
MANFCTG	Share of people in the work force in each community who work in the manufacturing industry for both durable and non-durable goods.
COMMUTE	Percent of people in a community who commute 15 minutes or less to work
NO _DIPLOMA	Share of people in each block group over the age of twenty-five who have completed some high school but have not received a diploma.
DIPLOMA	Share whose highest level of education is a high school diploma
DEGREE	Share in each community whose highest level of education is a Bachelor's Degree
ENTRANCE	A dummy variable taking the value of "1" if a community has gone not exposed in 1990 to exposed in 1995.
EXIT	A dummy variable taking the value of "1" if the block group has gone from exposed in 1990 to not exposed in 1995.
EXPOSURE VARIABLES	A dummy where a "1" indicates the community is exposed to a TRI within one mile and a "0" otherwise for 1990, 1995, and 2000.

Table 1: Variable Definitions (cont.)

EMISSIONS	The hazard score is calculated by the EPA's RSEI model and weights emissions by multiplying the annual pounds released by a risk score.
DELTA "D"	Calculated by subtracting the 1990 data from 2000[51].

[51] DINCOME, DHV, and DRENT are calculated using the Implicit Price deflators for GDP are provided by the Bureau of Economic Analysis using Tab1e.1.1.9. Last accessed on 5/3/2005. http://www.bea.doc.gov/bea/dn/nipaweb/TableView.asp?SelectedTable=13&FirstYear=1988&LastYear=2005&Freq=Qtr

Table 2: Descriptive Statistics for 1990 and 2000 Block Groups

Label	Summary for 1990		Summary for 2000	
	Mean	Std Dev	Mean	Std Dev
SQKILO	11.28	137.79	11.28	137.79
POPULATION	2007.66	46,137.3	2906.48	66793.43
DENSITY	4472.75	3572.3	5738.33	4307.70
SHWHITE	.833	.222	.764	.205
SHBLACK	.031	.068	.036	.055
SHNATIVE	.017	.060	.019	.054
SHASIA	.015	.026	.022	.0333
SHHISP	.152	.189	.249	.247
SHMIN	.200	.231	.303	.276
INCOME[52]*	33.5	18.18	47.8	23.9
POVERTY	.118	.135	.121	.130
OWN	.645	.300	.669	.295
RENT**	5.27	2.59	7.43	3.65
HOUSEVALUE*	85.1	54.6	122.8	92.2
EMISSIONS*	731	26,613	34,298	538,719
EXPOSURE (0,1)	0.20	0.40	0.25	0.44
MANUFCTG	.138	.080	.112	.071
COMMUTE	.251	.139	.236	.119
NO_DIPLOMA	.118	.085	.108	.083
DIPLOMA	.266	.115	.232	.097
DEGREE	.151	.113	.155	.109
Delta Variables 1990 – 2000				
DMIN	*	*	.089	.161
DDENSITY	*	*	1266	2119
DRENT**	*	*	.391	4.11
DHV*	*	*	9.21	64.56
DMANFG	*	*	-.026	.091
DCOMMUTE	*	*	-.015	.149
DEMISSIONS	*	*	16287	354035
ENTRANCE	*	*	0.04	0.20
EXIT	*	*	0.07	0.25

[52] Fields marked with * are measured in thousands and ** measured in hundreds.

Table 3: Probit Estimation of the Siting Decision

Variables	1995			
	M. Effects	**Estimates**	**Error**	**t value**
SHMIN	0.423	0.673**	0.267	2.520
OWN	-0.137	-0.2180*	0.121	-1.800
RENT	0.079	0.126**	0.058	2.160
RENTSQ	-0.004	-0.007	0.005	-1.430
INCOME	-0.002	-0.003	0.003	-1.010
DENSITY	-0.002	-0.003	0.006	-0.420
NO_DIPLOMA	0.126	0.200	0.327	0.610
DIPLOMA	0.143	0.228	0.255	0.890
DEGREE	0.552	0.878*	0.515	1.710
MANUFCTG	0.710	1.129**	0.577	1.960
COMMUTE	0.156	0.248	0.148	1.670
CONSTANT	-0.068	-1.345**	0.378	-3.560

Note: The dependent variable is EXPOSURE95 **Statistically significant at the 5% level or better. *Statistically significant at the 10% level.

Table 4: FGLS Estimation Reversing the Causality

Variables	2000		
	Estimates	**Error**	**t value**
EXPOSURE	0.096**	0.012	8.13
EMISSIONS	-1.92E-12	1.30E-11	-0.15
HOUSEVALUE	-3.43E-04**	4.83E-05	-7.11
RENT	-0.022**	0.001	-19.1
OWN	-0.100**	0.019	-5.18
MANUFCTG	0.534**	0.057	9.38
COMMUTE	-0.123**	0.035	-3.49
DENSITY	0.015**	0.001	13.24
CONSTANT	0.391**	0.020	19.7
R-Squared			0.4461
Observations			2105

Note: The dependent variable is SHMIN. ** Statistically significant at the 5% level or better.

Table 5: Simultaneous Estimation

Variables	Estimates	Error	t value
SHMIN	.92E-02**	.45E-02	2.038
MANFG	.011003**	.55E-02	2.004
DUM2000	.229310**	.104445	2.196
RENT	-.15E-03**	.74E-04	-1.966
INCOME	-.46E-02**	.23E-02	-1.977
CONSTANT	-.929464**	.107131	-8.675
EXPOSURE	44.806**	5.4545	8.215
OWN	-.03740**	.017667	-2.117
DENSITY	.52E-03**	.23E-03	2.284
DUM2000	-.648527*	3.0836	-.2103
CONSTANT	56.310**	4.2678	13.19
Log-Likelihood			-17151.9
Observations			4226

Note: The dependent variables are SHMIN and EXPOSURE. **Statistically significant at the 5% level or better. *Statistically significant at the 10% level.

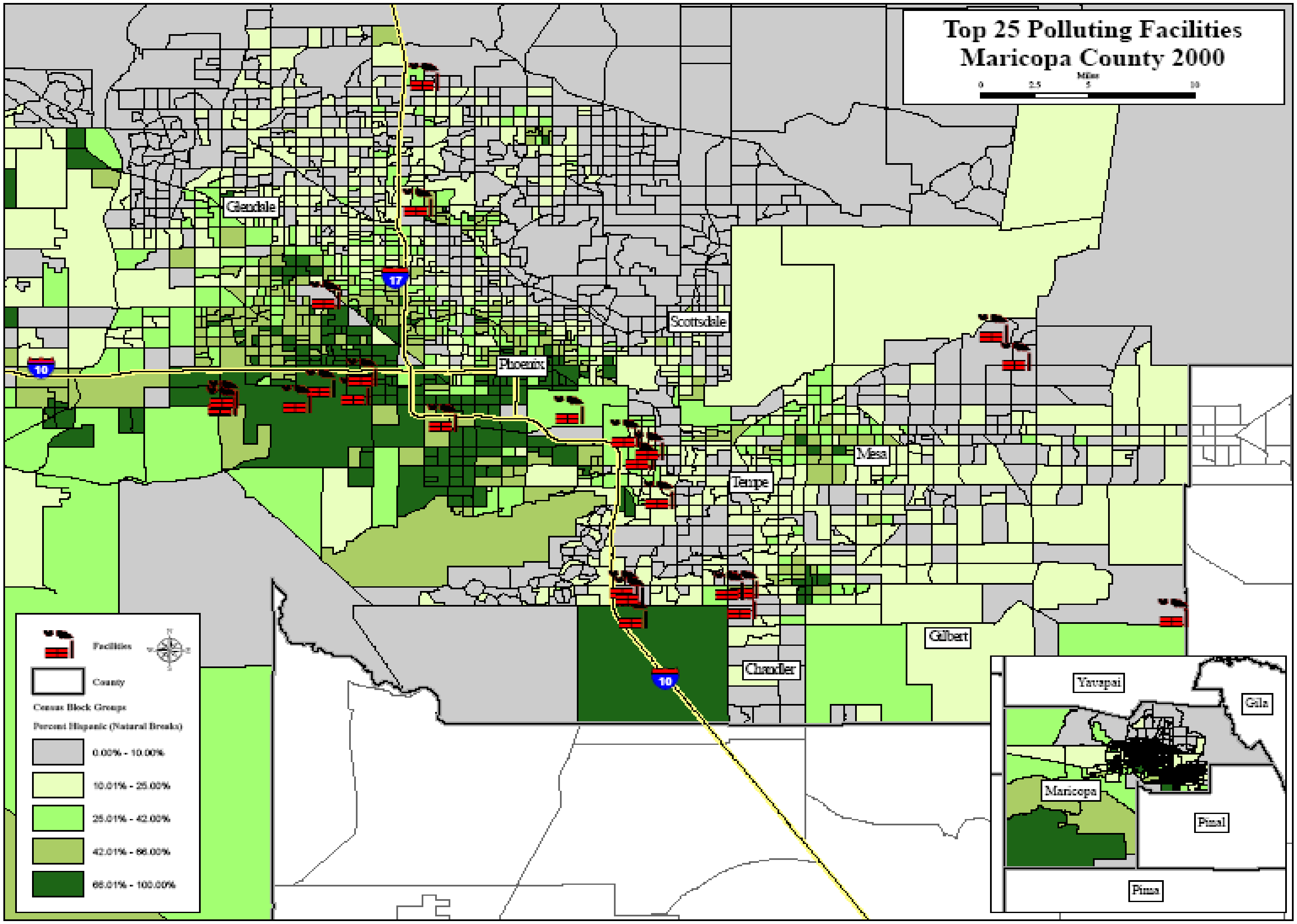
Table 6: FGLS Estimation of the Migration Effects

Variables	Estimates	Error	t value
DEMISSIONS	-1.64E-06**	4.54E-07	-3.610
ENTRANCE	2.804*	1.651	1.700
EXIT	-3.344**	1.557	-2.150
EXPOSURE90	4.086**	0.989	4.130
DHV	-0.027**	0.006	-4.630
DRENT	-0.654**	0.136	-4.820
DDENSITY	2.284**	0.160	14.260
DMANFG	2.988	3.684	0.810
DCOMMUTE	1.314	2.146	0.610
CONSTANT	5.752**	0.441	13.050
R-squared			0.1082
Observations			2105

Note: The dependent variable is DMIN. **Statistically significant at the 5% level or better. *Statistically significant at the 10% level.

Figure 1. Top 25 TRI Facilities, 1990

Figure 2. Top 25 TRI Facilities, 2000



Appendix 1

1990 TRI Facilities - Maricopa County

Name	Hazard	LAT	LONG
ABS METALLURGICAL PROCESSORS INC.	14,778	33.42	111.98
ACOUSTIC IMAGING TECHS. CORP.	24,120	33.35	111.97
ACT II PRINTED CIRCUITS INC.	1,690,000	33.38	111.95
AIR TUF PRODS. INC.	34,099	33.45	112.16
ALLIED-SIGNAL CO. GARRETT ENGINE DIV.	18,905	33.42	112.03
ALLIED-SIGNAL CO. GARRETT ENGINE DIV.	86,231	33.42	112.03
ALLIED-SIGNAL CO. GARRETT FLUID SYS. DIV.	206,447	33.34	111.96
ALLIED-SIGNAL CO. GARRETT GEN. SERVICES DIV.	226,939	33.42	111.96
ALLIED-SIGNAL INC. GARRETT AUX. PWR DIV.	17,460	33.44	112.03
AMERICAN AEROSPACE TECHNICAL CASTINGS INC.	43,000,000	33.41	112.02
AMERICAN FIBERGLASS	23,265	33.47	112.11
AMERICAN IND. DIVERSIFIED INC.	22,302	33.40	112.01
AMERON CONCRETE & STEEL PIPE GROUP	18,781,368	33.42	112.06
ANOCAD PLATING & PAINTING CO. INC.	16,535	33.44	112.19
ARIZONA MPP130130	136,220	33.45	112.17
ARIZONA PLATING & ANODIZING CO. INC.	105,700	33.44	112.07
BELDEN COMMUNICATIONS DIV.	1,396,770	33.45	112.17
BORDEN FOODS CO.	4,680,000	33.46	112.27
BULL HN INFORMATION SYS. INC.	10,904	33.30	111.96

BULL HN INFORMATION SYS. INC.	195,000	33.61	112.12
Name	**Hazard**	**LAT**	**LONG**
CONTINENTAL CIRCUITS CORP.	8,530,541	33.40	112.00
COPPER STATE RUBBER OF ARIZONA INC.	78,948	33.44	112.19
CORNING GILBERT INC.	193,211	33.51	112.17
COURTAULDS PERFORMANCE FILMS, INC.	772,618	33.30	111.96
CUSTOM BOLT MFG.	12,750	33.42	112.07
DELUXE CHECK PRINTERS INC.	23,958	33.43	111.96
DIGITAL EQUIPMENT CORP.	20,676	33.41	111.97
DOLPHIN INC.	1,966,855	33.44	112.19
D-VELCO MFG. OF ARIZONA INC.	56,821	33.44	112.00
F & B MFG. CO.	65,587	33.50	112.14
GANNON & SCOTT PHOENIX INC.	11,550	33.43	112.04
GENERAL DYNAMICS DECISION SYS.	458,620	33.46	111.90
GENERAL SEMICONDUCTOR, IND. INC.	68,150	33.42	111.97
GOETTL AIR CONDITIONING INC.	48,118	33.45	111.96
GOODRICH CORP. UNIVERSAL PROPULSION CO.	69,714	33.72	112.07
GOODRICH TURBOMACHINERY PRODS.	9,588,425	33.29	111.88
GOODRICH-AIRCRAFT INTERIOR PRODS.	424,514	33.41	112.07
GOULD ELECTRONICS INC.	6,340,710	33.31	111.89
HAMILTON SUNDSTRAND	102,393	33.65	112.11
HERAEUS INC. MATERIALS TECH. DIV.	4,690,587	33.31	111.96
HILL BROTHERS CHEMICAL CO.	35,563	33.51	112.16
HONEYWELL BRGA BELL ROAD	169,150	33.64	112.18
HONEYWELL ENGINES SYS. & SERVICES	1,222,402,997	33.43	112.00
HONEYWELL INC. IACD	15,300	33.58	112.12

HONEYWELL INTL. AIR TRANSPORT-PHOENIX	13,465,681	33.67	112.08
Name	**Hazard**	**LAT**	**LONG**
HUBBELL HERMETIC REFRIGERATION INC.	334,998	33.47	112.11
ICI COMPOSITES INC.	98,860	33.35	111.88
INERTIA DYNAMICS CORP.	798,000	33.31	111.97
INTEL MAIN CHANDLER CAMPUS	990,350	33.31	111.93
INX INTL. INK CO.	24,761	33.45	112.17
ITT CANNON PHOENIX PLANT	95,742	33.44	112.02
J. B. RODGERS MECHANICAL CONTRACTORS INC.	102,249	33.48	112.12
KACHINA TECHNICAL SERVICES & PROCESSES INC.	160,931	33.45	112.02
KARSTEN PRECISION HEAT TREAT DIV.	1,429,758	33.50	112.12
L & M LAMINATES & MARBLE	4,722	33.42	112.06
LAMINATE TECH. CORP.	465,025	33.40	111.95
LINATEX CORP. OF AMERICA	83,700	33.41	111.99
LINCOLN LASER CO.	83,540	33.43	112.07
LITTON ELECTRO-OPTICAL SYS.	102,591	33.43	111.97
LORAL DEFENSE SYS. ARIZONA	18,635	33.44	112.36
MAAX SPAS ARIZONA INC.	22,680	33.21	111.84
MAIL-WELL ENVELOPE	14,738	33.45	112.16
MARLAM INDUSTIES INC.	11,412	33.43	112.06
MARLYN NUTRACEUTICALS NATURALLY VITAMIN SUPPLEMENTS	385	33.62	111.92
MASTERCRAFT CABINETS INC.	630,450	33.41	111.86
MAXIMET CORP.	38,565	33.45	112.19
MCCARTHY CABINET CO.	66,145	33.49	112.13
MCDONNELL DOUGLAS HELICOPTER CO.	63,278	33.47	111.72

ME GLOBAL INC.	1,739,100	33.37	111.94
Name	**Hazard**	**LAT**	**LONG**
MEDTRONIC TEMPE	128,381	33.42	111.97
MESA FULLY FORMED INC.	805	33.39	111.83
MICROCHIP TECH. INC.	39,416	33.30	111.88
MICROSEMI CORP.	43,896	33.48	111.89
MOTOROLA - MESA	7,632,230	33.41	111.88
MOTOROLA COMPUTER GROUP	79,628	33.41	111.97
MOTOROLA INC. GSTG	81,328	33.27	111.88
MOTOROLA SCG	5,403,430	33.46	111.97
MOTOROLA TEMPE	13,780	33.35	111.90
MUNTERS CORP.	53,958	33.45	112.01
MURCO WALL PRODS. INC.	1,125	33.38	112.57
NEW NGC INC.	23	33.44	112.05
OBERG ARIZONA	35,015	33.30	111.96
OHLINGER IND. INC.	30,600	33.67	112.08
OLIN HUNT SPECIALTY PRODS.	23,228	33.35	111.83
PARKER HANNIFIN CORP. GTFSD OVERHAUL	34,920	33.55	112.28
PATTERSON LABS. INC. (DBA PATTERSON W.)	45,000	33.45	112.17
PIMA VALVE INC.	187,500	33.29	111.95
PIMALCO INC.	4,618	33.28	111.96
PING INC.	804,024	33.58	112.10
PLYMOUTH TUBE CO.	1,680,000	33.28	111.95
PRECISION DIE & STAMPING INC.	45,050	33.42	111.97
PROCTER & GAMBLE MFG. CO.	12,193,020	33.43	112.13
PROFESSIONAL CHEMICALS CORP.	89,069	33.30	111.89

PYRAMID SHEET METAL DIV.	1,844,136	33.50	112.14
Name	**Hazard**	**LAT**	**LONG**
REXAM BEVERAGE CAN CO. PHOENIX AZ FACILITY	19,825,229	33.45	112.17
ROGERS CORP. ACMD-DOBSON	7,071	33.30	111.95
ROGERS CORP. ACMD-ROOSEVELT	11,250	33.31	111.88
ROGERS CORP. CIG	1,168,702	33.31	111.88
ROGERS CORP. PDD	33,000	33.45	111.71
SANMINA-SCI CORP. PHOENIX DIV.	3,037,500	33.40	112.00
SANTOKU AMERICA INC.	70,000	33.45	112.24
SCHUFF STEEL CO.	10,350	33.44	112.10
SEA RAY BOATS INC.	203,400	33.41	111.99
SUB ZERO FREEZER CO. INC.	285,600	33.46	112.14
SUNBURST SHUTTERS INC.	80,100	33.42	112.00
TALLEY DEFENSE SYS. INC.	8,975	33.48	111.73
TALLEY DEFENSE SYS. INC.	1,769,534	33.45	111.73
TALLEY DEFENSE SYS. INC. BURN GROUND	11,844,000	33.49	111.71
TALLEY DEFENSE SYS. INC. PLANT 4	20,774	33.49	111.71
TESSENDERLO KERLEY INC.	650	33.42	112.11
TREFFERS PRECISION INC.	668,750	33.46	112.11
TRIUMPH CORP.	64,800	33.41	111.95
TRW VEHICLE SAFETY SYS. MESA I FACILITY	35,499,001	33.49	111.71
ULTRA INSTALLATIONS INC.	134,259	33.41	111.85
VERCO MFG. CO.	21,600	33.50	112.15
WALBAR INC. ARIZONA DIV.	48,425	33.41	111.95
WEAVER QUALITY SHUTTERS	49,500	33.44	112.05
WESTERN BONDED PRODS. INC. FLEX FOAM	26,182,580	33.46	112.10

WOODSTUFF MFG. INC.	3,184,077	33.44	112.15
Name	**Hazard**	**LAT**	**LONG**
WORLD RESOURCES CO.	30,700,250	33.44	112.24

Appendix 2			
1995 TRI Facilities - Maricopa County			
Name	**Hazard**	**LAT**	**LONG**
A N R MFG. LTD.	9,540	33.34	111.93
ALLIED TOOL & DIE CO. INC.	8,910,750	33.41	112.06
ALLIED TUBE & CONDUIT - PHOENI	1,617,210	33.48	112.13
AMERICAN CHEM-TECH INC.	1,800	33.43	112.02
AMERICAN FIBERGLASS	11,997	33.42	112.11
ANOCAD PLATING & PAINTING	20,522	33.44	112.19
ARIZONA CASTINGS INC.	85,837,500	33.43	111.90
ARIZONA GALVANIZING INC.	8,746,857	33.37	112.39
ARIZONA MARBLE IND. INC.	1,436	33.33	112.06
ARIZONA MPP130130	141,400	33.45	112.17
AVONTI MFG. INC.	7,441	33.85	112.13
BELDEN COMMUNICATIONS DIV.	12,954,360,000	33.44	112.24
CARDINAL INDL. FINISHES INC.	63,396	33.42	112.00
CHEMRESEARCH CO. INC.	2,110,796,898	33.46	112.10
COPLIN MFG. INC.	12,173	33.53	112.18
CORELLA ELEC WIRE & CABLE	661,147,500	33.51	112.04
CORNING GILBERT INC.	1,950,650	33.51	112.17
CORNING GILBERT INC.	42,000	33.50	112.16
DOLPHIN INC.	20,887,504,750	33.44	112.19
DYNACO CORP.	12,291,750	33.42	111.95

Name	**Hazard**	**LAT**	**LONG**
FIBER FAB INC.	17,717	33.36	111.80
GOLD TECH. INDS. AERO/TEL	1,274,000	33.44	111.91
GOODRICH TURBOMACHINERY	225,000,000	33.29	111.88
GOODRICH-AIRCRAFT INTERIOR	281,687	33.41	112.07
GOULD ELECTRONICS INC.	2,831,959,712	33.31	111.89
HERAEUS INC. MATERIALS TECH	87,075,000	33.31	111.96
HERITAGE SHUTTERS INC.	200,561	33.68	112.19
HILL BROTHERS CHEMICAL CO.	2,250,700	33.51	112.16
HONEYWELL ENGINES SYS & SER	15,606,206,482	33.43	112.00
HONEYWELL SSG	33,847	33.66	112.19
INNOVEX SOUTHWEST INC.	100,545,750	33.31	111.88
INTEL MAIN CHANDLER CAMPUS	1,639,763	33.31	111.93
INX INTL. INK CO.	13,262	33.45	112.17
ISOLA LAMINATE SYS.	22,008	33.30	111.83
JMI - PHOENIX LABS. INC.	165,213	33.43	111.89
KACHINA TECHNICAL SERVICES	53,980	33.45	112.02
KARSTEN PRECISION HEAT TREAT	833,780	33.50	112.12
L & M LAMINATES & MARBLE	32,234	33.40	112.07
LAMINATE TECH. CORP.	122,379,586	33.40	111.95
LITTON ELECTRO-OPTICAL SYS.	45,037	33.43	111.97
MAAX SPAS ARIZONA INC.	51,916	33.21	111.84
MAGOTTAUX CHANDLER INC.	708,827,500	33.23	111.84
MARCOR IND. INC.	3,960	33.44	112.15

MARLAM INDUSTIES INC.	4,680	33.43	112.06
MASTERCRAFT CABINETS INC.	152,889	33.41	111.86
MCCARTHY CABINET CO.	124,812	33.49	112.13
MCDONNELL DOUGLAS HELICOPTER	56,423	33.47	111.72
ME GLOBAL INC.	1,890,767,225	33.37	111.94
MESA FULLY FORMED INC.	120,270	33.39	111.83
METCO METAL FINISHING INC.	2,322,013	33.40	112.02
MICROCHIP TECH. INC.	32,500	33.31	111.88
MICROSEMI CORP.	334,555	33.48	111.89
MONIER LIFETILE L.L.C.	177,245,000	33.43	112.17
MOSAIC PRINTED CIRCUITS L.L.C.	73,420,500	33.39	112.03
MOTOROLA - MESA	9,839,053	33.41	111.88
MOTOROLA CHANDLER	133,805	33.32	111.86
MOTOROLA SCG	5,075,663	33.47	112.02
MOTOROLA TEMPE	24,600	33.35	111.90
NELTEC INC.	67,441,777	33.42	111.96
NORTHROP GRUMMAN	240,970	33.30	111.89
OBERG ARIZONA	4,596,511,000	33.30	111.96
OLIN HUNT SPECIALTY PRODS.	12,408	33.35	111.83
PATRICIAN MARBLE CO. L.L.P.	45,394	33.49	112.13
PATTERSON LABS. INC.	90,000	33.45	112.17
PATTERSON WEST	90,000	33.41	112.40
PENN RACQUET SPORTS	443,496	33.45	112.16
PIMA VALVE INC.	32,986,500	33.29	111.95

PIMALCO INC.	312,920,313	33.28	111.96
PING INC.	2,074,048,250	33.58	112.10
PROFESS. CHEMICALS CORP.	180,180	33.30	111.89
REXAM BEVERAGE CAN CO	16,026,220	33.50	112.17
ROGERS CORP. ACMD-DOBSON	27,729	33.30	111.95
ROGERS CORP. ACMD-ROOS.	100,185,000	33.31	111.88
SANMINA-SCI CORP	440,265,081	33.40	112.01
SCHREIBER FOODS INC.	4,750,480	33.41	111.95
SCHUFF STEEL CO.	6,587	33.45	112.13
SEA RAY BOATS INC.	367,440	33.41	111.99
SERVICE WIRE CO. GLENDALE AZ	93,080,250	33.52	112.17
SOUTH BAY CIRCUITS INC.	11,697,750	33.30	111.95
SOUTHWEST ALUMINUM SYS.	4,752	33.30	111.96
SOUTHWEST DISTRIBUTING CO.	43,800	33.40	111.84
STMICROELECTRONICS INC.	33,215	33.64	112.06
SUB ZERO FREEZER CO. INC.	367,588,750	33.46	112.14
SURFACE TEK SPECIALTY PRODS.	107,600	33.62	111.90
TESSENDERLO KERLEY INC.	47,710	33.42	112.11
TRANS-MATIC MFG. INC.	125,400,000	33.42	111.92
TREFFERS PRECISION INC.	688,350	33.46	112.11
TRIUMPH CORP.	1,448,580	33.40	111.90
TRW VEHICLE SAFETY SYS. MESA	8,369,624,668	33.49	111.71
TRW VEHICLE SAFETY SYS. MESA	14,287,121,817	33.28	111.59
ULTRA INSTALLATIONS INC.	17,010	33.41	111.85

Name	Hazard	LAT	LONG
WALBAR INC. ARIZONA DIV.	1,044,000,000	33.41	111.95
WALLNOX ENTERPRISES	70,081	33.68	112.08
WESTERN BONDED PRODS. INC	1,256,689	33.45	112.17
WESTERN STATES PETROLEUM	300	33.44	112.09
WOODSTUFF MFG. INC.	13,121	33.44	112.15
WORLD RESOURCES CO.	187,500	33.44	112.23

Appendix 3

2000 TRI Facilities - Maricopa County

Name	Hazard	LAT	LONG
A N R MFG. LTD.	21,600	33.34	111.93
ABLE STEEL FABRICATORS INC.	358,812,000	33.47	111.70
ACME ELECTRIC CORP. AEROSPACE	257,760,050	33.41	111.95
ALLIED TUBE & CONDUIT - PHOENI	586,755	33.48	112.13
AMERICAN FIBERGLASS	20,077	33.42	112.11
ARCH CHEMICALS INC.	19,814,695	33.30	111.59
ARIZONA CASTINGS INC.	57,787,500	33.43	111.90
ARIZONA GALVANIZING INC.	30,884,733	33.37	112.39
ARIZONA MARBLE IND. INC.	1,647	33.33	112.06
ARIZONA MPP130130	56,000	33.45	112.17
ASHLAND DISTRIBUTION CO.	61,963	33.30	111.96
ASPEN FURNITURE L.L.C.	2,250,000	33.48	112.12
ASPEN FURNITURE L.L.C.	2,070,000	33.49	112.14
AVONTI MFG. INC.	3,001	33.68	112.08
BELDEN COMMUNICATIONS DIV.	11,050,509,750	33.44	112.24
BOC EDWARDS KACHINA	70,000	33.42	112.00
BP PHOENIX TERMINAL	2,907,374	33.46	112.18
CERITA WEST L.L.C.	52,590	33.36	111.96
CHEMRESEARCH CO. INC.	1,063,193,350	33.43	112.09
CHEVRON PRODS. CO. PHOENIX TER	226,370	33.45	112.17
CHROMALLOY ARIZONA	1,528,515,700	33.45	112.17

CONOCOPHILLIPS PHOENIX TERMINA	20,180	33.45	112.17
Name	**Hazard**	**LAT**	**LONG**
CORNING GILBERT INC.	22,500	33.50	112.16
DOLPHIN INC.	1,578,384,419	33.44	112.19
DUREL CORP.	981,758	33.31	111.88
DYNACO CORP.	11,005,500	33.42	111.95
EARL'S FIBERGLASS	19,652	33.43	112.07
EQUILON PHOENIX SALES TERMINAL	194,839	33.45	112.17
FIBER FAB INC.	17,895	33.36	111.80
GEM MICROELECTRONIC MATERIALS	2,115	33.36	111.83
GOLD TECH. INDS. AEROSPACE/TEL	3,500	33.44	111.91
GOODRICH TURBOMACHINERY PRODS.	278,129,000	33.29	111.88
GOODRICH-AIRCRAFT INTERIOR PRO	217,487	33.41	112.07
GOULD ELECTRONICS INC.	2,106,834,790	33.31	111.89
GRIGGS PAINT	18,000	33.41	112.05
HARTSON-KENNEDY CABINET TOP CO	12,856	33.55	112.29
HERAEUS INC. MATERIALS TECH. D	3,687,347,170	33.31	111.96
HILL BROTHERS CHEMICAL CO.	2,250,000	33.51	112.16
HONEYWELL ENGINES SYS. & SERVI	21,307,525,148	33.43	112.00
IMSAMET OF ARIZONA	612,000	33.58	112.00
INNOVEX SOUTHWEST INC.	42,138,775	33.31	111.88
INTEL CORP.	816,825	33.24	111.89
INTEL MAIN CHANDLER CAMPUS	280,069	33.31	111.93
INTERNATIONAL TECHNICAL COATIN	428,539,750	33.45	112.15
INX INTL. INK CO.	892,021	33.45	112.17
ISOLA LAMINATE SYS.	60,942,511	33.30	111.89

ITI FINISHING	36,728	33.43	111.97
Name	**Hazard**	**LAT**	**LONG**
KULICKE & SOFFA FLIP CHIP DIV.	4,998,870	33.42	112.00
L & M LAMINATES & MARBLE	53,618	33.42	112.06
L & S FIBERGLASS INC.	14,690	33.45	112.03
LAMINATE TECH. CORP.	385,390,500	33.40	111.95
LEGENDS FURNITURE INC.	1,692,000	33.52	112.17
LITTON ELECTRO-OPTICAL SYS.	1,804,229	33.43	111.97
MAAX SPAS ARIZONA INC.	249,372	33.21	111.84
MARLAM INDUSTIES INC.	80,620	33.43	112.06
MASTERCRAFT CABINETS INC.	462,949	33.41	111.86
MCCARTHY CABINET CO.	5,000	33.49	112.13
ME GLOBAL INC.	2,799,136,499	33.37	111.94
MESA FULLY FORMED INC.	100,885	33.39	111.83
METCO METAL FINISHING INC.	4,132,049	33.40	112.02
MGC PURE CHEMICALS AMERICA INC	228,060	33.29	111.59
MICROCHIP TECH. INC.	404,690	33.30	111.88
MICROCHIP TECH. INC.	114,140	33.42	111.97
MICROSEMI CORP.	14,040	33.48	111.89
MORTON INTL. INC. (OPER BY SH	27,040	33.63	111.90
MOSAIC PRINTED CIRCUITS L.L.C.	62,002,500	33.39	112.03
MOTOROLA - MESA	2,732,358	33.41	111.88
MOTOROLA CHANDLER	598,064	33.32	111.86
MOTOROLA SCG	275,446	33.46	111.97
MOTOROLA TEMPE	4,133,505	33.35	111.90
MUNTERS CORP.	4,002,000	33.43	112.19

NELCO ARIZONA	6,812	33.40	111.95
Name	**Hazard**	**LAT**	**LONG**
OBERG ARIZONA	11,524,600,750	33.30	111.96
PATRICIAN MARBLE CO. L.L.P.	24,610	33.49	112.13
PENN RACQUET SPORTS	361,335	33.45	112.16
PHOENIX BRICK YARD	10,530,000	33.43	112.08
PHOENIX HEAT TREATMENT	105,000	33.43	112.11
PIMALCO INC.	697,555,640	33.28	111.96
PING INC.	643,486,999	33.58	112.10
PRAXAIR DISTRIBUTION INC.	1,800	33.44	112.14
PRESTO CASTING CO.		33.51	112.18
PROCLEAN OF ARIZONA INC.	67,500	33.45	112.15
PROFESSIONAL CHEMICALS CORP.	288,630	33.30	111.89
REVLON CONSUMER PRODS. CORP.	83,015	33.43	112.16
REXAM BEVERAGE CAN CO. PHOENIX	12,466,081	33.45	112.17
ROGERS CORP. ACMD-DOBSON	9,303	33.30	111.95
ROGERS CORP. ACMD-ROOSEVELT	316,513,402	33.31	111.88
ROMIC ENVIRONMENTAL TECHS. INC	11,253,633	33.29	111.96
ROYAL STONE INDS.	2,383	33.48	112.12
SANMINA-SCI CORP. PHOENIX DIV.	74,738,135	33.40	112.00
SANTOKU AMERICA INC.	240,030,000	33.45	112.24
SCHREIBER FOODS INC.	1,400	33.41	111.95
SCHUFF STEEL CO.	204,228	33.44	112.10
SCI L.L.C. ON SEMICONDUCTOR	478,733	33.46	111.97
SEA RAY BOATS INC.	563,725	33.41	111.99
SERVICE WIRE CO. GLENDALE AZ	196,311,000	33.52	112.17

SMM L.L.C.	118,317,750	33.68	112.10
Name	**Hazard**	**LAT**	**LONG**
SOUTHWEST DISTRIBUTING CO.	5,880	33.40	111.84
STMICROELECTRONICS INC.	19,240	33.64	112.06
SUB ZERO FREEZER CO. INC.	626,818,750	33.46	112.14
SUMCO SOUTHWEST CORP.	236,790	33.65	112.98
SUPER RADIATOR COILS	866,832	33.42	112.04
TARR INC.	16,973	33.50	112.15
TRANS-MATIC MFG. INC.	61,125,000	33.35	111.97
TREFFERS PRECISION INC.	70,000	33.46	112.11
TRENWYTH INDS.	853	33.50	112.15
TRIUMPH CORP.	406,560	33.41	111.95
TRW VEHICLE SAFETY SYS. MESA I	2,342,130,754	33.49	111.71
TRW VEHICLE SAFETY SYS. MESA I	6,324,040,942	33.29	111.59
ULTRA INSTALLATIONS INC.	28,674	33.41	111.85
UNIVAR USA INC. (FORMERLY VOPA	173,542	33.45	112.16
VAW OF AMERICA INC.	11,658,240	33.45	112.17
W. R. MEADOWS OF ARIZONA INC.	940,000	33.42	112.44
WALLNOX ENTERPRISES (DBA DESER	88,133	33.68	112.08
WESTERN BONDED PRODS. INC. FLE	138,220	33.45	112.10
WESTERN STATES PETROLEUM	273,938	33.44	112.09
WESTERN STATES PETROLEUM	585	33.41	112.13
WORLD RESOURCES CO.	3,640,017,000	33.44	112.24

Appendix 4: Simultaneous Equations

The simultaneous model used for explaining siting decision and reverse caus
is given by:

(1) $$EXPOSURE^{*}_{it} = b_0 + b_{00} \cdot DUM2000_{it} + b_1 \cdot MANUFCTG_{it} + b_2 \cdot INCOME_{it} + b_3 \cdot RENT_{it} + \gamma_1 \cdot SHMIN_{it} + u_{1it}$$

$$EXPOSURE_{it} = \begin{cases} 0 \text{ if } EXPOSURE^{*}_{it} \leq 0 \\ 1 \text{ if } EXPOSURE^{*}_{it} > 0 \end{cases}$$

and

(2)
$$SHMIN_{it} = c_0 + c_{00} \cdot DUM2000_{it} + c_1 \cdot SHOWN_{it} + c_2 \cdot POPDEN_{it} + \gamma_2 \cdot EXPOSURE^{*}_{it}$$

where, $b_0, b_{00}, b_1, b_2, b_3, c_0, c_{00}, c_1, c_2, \gamma_1, \gamma_2$ are parameters to be estimated, u_{1it} and u_{2it} disturbance terms, *DUM2000* is a dummy variable for year 2000 and other variables as given in Table 4.1. The structural model given in equations (1) and (2) is simultaneous with unobservable endogenous variable on the right hand side of (2). estimation procedure should account for this simultaneity and possible correlation between u_1 and u_2 to obtain consistent and efficient parameter estimates. Traditiona instrumental methods are not feasible because of the unobservable nature of the endogenous variable on the right hand side of (2)[53]. We derive the reduced form mo from the structural model and estimate it with full information maximum likelihood methods.

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[53] A simultaneous model with observed binary variable, *EXPOSURE,* instead of unobservable $EXPOSURE^{*}$, on the right hand side of (2) is internally inconsistent and cannot be estimated unless $\gamma_1 = 0$ or $\gamma_2 = 0$. See Maddala, pages 117-118.

We assume that error terms in equations (1) and (2) are jointly normally distributed as:

(3) $$\begin{pmatrix} u_{1it} \\ u_{2it} \end{pmatrix} \sim N\left[\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} 1 & \sigma_{12} \\ \sigma_{12} & \sigma_{22} \end{pmatrix}\right].$$

As is customary in probit models, the variance of u_1 has been normalized to 1. The structural model given in equations (1) and (2) can be written in its reduced form as:

(4) $$y^*_{1it} = \left(xb_{1it} + \gamma_1 \cdot xb_{2it}\right) / \left(1 - \gamma_1 \cdot \gamma_2\right) + \varepsilon_{1it} = rhs_{1it} + \varepsilon_{1it}$$

(5) $$y_{2it} = \left(xb_{2it} + \gamma_2 \cdot xb_{1it}\right) / \left(1 - \gamma_1 \cdot \gamma_2\right) + \varepsilon_{2it} = rhs_{2it} + \varepsilon_{2it}$$

where, y_{1it} is *EXPOSURE$_{it}$*, y_{2it} is *SHMIN$_{it}$,*

$$xb_{1it} = b_0 + b_{00} \cdot DUM2000_{it} + b_1 \cdot MANUFCTG_{it} + b_2 \cdot INCOME_{it} + b_3 \cdot RENT_{it}$$

,

$$xb_{2it} = c_0 + c_{00} \cdot DUM2000_{it} + c_1 \cdot SHOWN_{it} + c_2 \cdot POPDEN_{it},$$

$$\varepsilon_{1it} = (u_{1it} + \gamma_1 \cdot u_{2it}) / (1 - \gamma_1 \cdot \gamma_2), \text{ and}$$

$$\varepsilon_{2it} = (\gamma_2 \cdot u_{1it} + u_{2it}) / (1 - \gamma_1 \cdot \gamma_2).$$

Given that u_{1it} and u_{2it} are normally distributed random variables, ε_{1it} and ε_{2it} are also normally distributed. That is,

(6) $$\begin{pmatrix} \varepsilon_{1it} \\ \varepsilon_{2it} \end{pmatrix} \sim N\left[\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} s_{11} & s_{12} \\ s_{12} & s_{22} \end{pmatrix}\right]$$

$$\text{where,} \quad \begin{bmatrix} s_{11} & s_{12} \\ s_{12} & s_{22} \end{bmatrix} = \begin{bmatrix} \dfrac{1+\gamma_1^2\sigma_{22}+2\gamma_1\sigma_{12}}{(1-\gamma_1\gamma_2)^2} & \dfrac{\gamma_2+\gamma_1\sigma_{22}+(1+\gamma_1\gamma_2)\sigma_{12}}{(1-\gamma_1\gamma_2)^2} \\ \dfrac{\gamma_2+\gamma_1\sigma_{22}+(1+\gamma_1\gamma_2)\sigma_{12}}{(1-\gamma_1\gamma_2)^2} & \dfrac{\gamma_2^2+\sigma_{22}+2\gamma_2\sigma_{12}}{(1-\gamma_1\gamma_2)^2} \end{bmatrix}.$$

Note that, the conditional distribution for $\varepsilon_{1it} \mid \varepsilon_{2it}$ is also normal and is given by:

(7) $\varepsilon_{1it} \mid \varepsilon_{2it} \sim N\left[(s_{12}/s_{22})\cdot\varepsilon_{2it}, \quad s_{11}\cdot(1-\rho^2)\right]$, where $\rho = \dfrac{s_{12}}{\sqrt{s_{11}\cdot s_{22}}}$ is the correlation coefficient.

Because pooled data from two different time periods (1990 and 2000) are used for estimation of model parameters, error terms are allowed to exhibit time-wise heteroscedasticity. Time varying heteroscedasticity is accommodated by rewriting the variances and covariances as:

(8a) $\sigma_{12it} = \sigma_{12a} + \sigma_{12b} DUM2000_{it}$

(8b) $\sigma_{22it} = \sigma_{22a} + \sigma_{22b} DUM2000_{it}$

Under the formulation in (8a) and (8b), a test for heteroscedasticity is conducted by simply testing the hypothesis, $\sigma_{12b} = \sigma_{22b} = 0$. Obviously, when error terms u's are heterscedastic, error terms ε's, being linear functions of u's, are also heteroscedastic. In particular, s_{11}, s_{12}, s_{22} and ρ are also time varying when heteroscedasticity is allowed.

Full information maximum likelihood estimates of the parameters ($b_0, b_{00}, b_1, b_2, b_3, c_0, c_{00}, c_1, c_2, \gamma_1, \gamma_2, \sigma_{12a}, \sigma_{12b}, \sigma_{22a}, \sigma_{22b}$) are obtained by maximizing the following log-likelihood function:

(9) $\ln L = \sum_{it\in(y_{1it}=1)} \ln prob\left(y_{1it}=1 \mid y_{2it}\right) + \sum_{it\in(y_{1it}=0)} \ln prob\left(y_{1it}=0 \mid y_{2it}\right) + \sum_{t=1}^{2}\sum_{i=1}^{n} \ln f\left(y_{2it}\right)$

where, $f\left(y_{2it}\right) = f\left(\varepsilon_{2it} - rhs_{2it}\right)$is a marginal distribution. The conditional probabilities in (9) can be evaluated using results in (7).

$$prob\left(y_{1it}=1 \mid y_{2it}\right) \quad = prob\left(y_{1it}^{*} > 0 \mid y_{2it}\right)$$

$$= prob\left(\varepsilon_{1it} > -rhs_{1it} \mid y_{2it}\right)$$

Conditioning on y_{2it} is equivalent to conditioning on ε_{2it} because, given exogenous variables and y_{2it}, ε_{2it} can be obtained using (5). Hence, the conditional probability can be written as,

$$prob\left(\varepsilon_{1it} > -rhs_{1it} \mid y_{2i}\right) \quad = \quad prob\left(\varepsilon_{1it} > -rhs_{1it} \mid \varepsilon_{2it}\right)$$

$$= prob\left(\varepsilon_{1it} < rhs_{1it} \mid \varepsilon_{2it}\right)$$

Subtracting the mean and dividing by the variance of the conditional distribution from both sides of the above inequality, we get

$$prob\left(\varepsilon_{1it} < rhs_{1it} \mid \varepsilon_{2it}\right) \quad = prob\left(\frac{\varepsilon_{1it} - \left(s_{12}/s_{22}\right)\cdot\varepsilon_{2it}}{\sqrt{s_{11}\cdot\left(1-\rho^{2}\right)}} < \frac{rhs_{1it} - \left(s_{12}/s_{22}\right)\cdot\varepsilon_{2it}}{\sqrt{s_{11}\cdot\left(1-\rho^{2}\right)}} \mid \varepsilon_{2it}\right)$$

$$= prob\left(z < \frac{rhs_{1it} - \left(s_{12}/s_{22}\right)\cdot\varepsilon_{2it}}{\sqrt{s_{11}\cdot\left(1-\rho^{2}\right)}} \mid \varepsilon_{2it}\right)$$

$$= \Phi\left(\frac{rhs_{1it} - \left(s_{12}/s_{22}\right)\cdot\varepsilon_{2it}}{\sqrt{s_{11}\cdot\left(1-\rho^{2}\right)}}\right)$$

$$= \Phi\left(\frac{rhs_{1it} - (s_{12}/s_{22})\cdot(y_{2it} - rhs_{2it})}{\sqrt{s_{11}\cdot(1-\rho^2)}}\right)$$

where **Φ** is the cumulative standard normal distribution. The second conditional probability in (9) can be evaluated in a similar way.

$$\begin{aligned} prob(y_{1it} = 0 \mid y_{2it}) &= prob(y_{1it}^* < 0 \mid y_{2it}) \\ &= prob(\varepsilon_{1it} < -rhs_{1it} \mid y_{2it}) \\ &= prob(\varepsilon_{1it} < -rhs_{1it} \mid \varepsilon_{2it}) \\ &= \Phi\left(\frac{-rhs_{1it} - (s_{12}/s_{22})\cdot(y_{2it} - rhs_{2it})}{\sqrt{s_{11}\cdot(1-\rho^2)}}\right) \end{aligned}$$

Using the expressions derived for conditional probabilities, the log-likelihood function in (9) can now be written in its final form as:

$$\begin{aligned} (10)\quad \ln L &= \sum_{t=1}^{2}\sum_{i=1}^{n} y_{1it}\cdot\ln\Phi\left(\frac{rhs_{1it} - (s_{12it}/s_{22it})\cdot(y_{2it} - rhs_{2it})}{\sqrt{s_{11it}\cdot(1-\rho_{it}^2)}}\right) \\ &+ \sum_{t=1}^{2}\sum_{i=1}^{n}(1-y_{1it})\cdot\ln\Phi\left(\frac{-rhs_{1it} - (s_{12it}/s_{22it})\cdot(y_{2it} - rhs_{2it})}{\sqrt{s_{11it}\cdot(1-\rho_{it}^2)}}\right) \\ &- \sum_{t=1}^{2}\sum_{i=1}^{n} 0.5\ln s_{22it} - 0.5\sum_{t=1}^{2}\sum_{i=1}^{n}(y_{2it} - rhs_{2it})^2 / s_{22it} \end{aligned}$$