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Three essays on relationships between the public sector and population migration

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Abstract

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This dissertation is a collection of papers examining the consequences and determinants of population migration at the state and county level. The first chapter introduces the importance of domestic migration in the United States and briefly presents the issues that are covered in this work. The second chapter focuses on the possibility that state outmigration could result in reduced support of public higher education. Some authors have hypothesized that forward-looking state legislators respond to outmigration of certain age groups by reducing appropriations to higher education. In the empirical model, outmigration is disaggregated into six age groups to examine varying effects of migration on public finances over the life-cycle. The third chapter shifts focus to consider environmental contamination as a determinant of county migration flows. While a number of location-specific amenities have been considered in the migration literature, a rigorous examination of the effects of environmental degradation is absent. The spatial autoregressive model is utilized to account for spatial dependence in the measurements of inmigration, outmigration, and net migration disaggregated by poverty status. The results show that toxic chemical releases reduce the rate of inmigration and net migration for the poor and nonpoor. Hazardous air pollutant emissions are then introduced to the model and are associated with a decreased rate of inmigration and outmigration for the poor and nonpoor. The fourth chapter is an extension of the third and considers the effects of air pollution and air quality on county migration flows. Substantial differences could exist between migrant responses to the measures of contamination in the third chapter and the air quality measures used in this chapter. Air pollution is strictly regulated and air quality information is widely available. The estimates show that increased air pollutant emissions reduce nonpoor inmigration, outmigration, and net migration and poor inmigration and outmigration. The effects of nonattainment designation for exceeding allowable ambient concentrations are more pronounced. The results are confirmed when alternate measures of emissions and air quality are employed. The fifth chapter concludes and discusses future extensions.

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Chapter 1:

Introduction

1.1 Introduction

Geographic mobility has long been an important component of the economy in the United States. From 1995 to 2000, more than 22 million domestic residents relocated to a different state and of those migrants approximately half moved to a different Census region. Not all states were affected equally by migration over this time period. Mobility is the major determinant of demographic composition and change for any area given the current stability of birth and death rates in the United States. The movement of individuals and households has important implications for the mover(s) and also for the origin and destination locations. Understanding movements of the population is critical for state and local governments making taxation and expenditure decisions. For private enterprise, population migration affects wages and production and the ability to sell goods and services. Migration also has the ability to alter the political map at the local, state, and federal level. This dissertation focuses on the relationship between migration and specific local, state and federal government policies.

State governments, and to a lesser extent, local governments invest substantially in public higher education in the form of annual appropriations. Level of appropriations varies significantly between states and the higher education budgeting process is idiosyncratic. State support for higher education has declined recently and a few authors in the public finance and regional science literatures have proposed that migration plays a role in appropriations decisions. If a state experiences persistent outmigration of individuals educated at state public universities, legislators may observe this pattern, anticipate its continuation, and reduce appropriations to public universities in response. The loss of the external benefits of education is negatively capitalized in public higher education expenditures. In this part of the dissertation, a theoretical model is developed to explain the relationship between migration and spending on public higher education. An empirical model is then estimated to test the conclusions. The empirical estimation relies on state outmigration flows disaggregated by age to allow for a more thorough analysis of the relationship. Outmigration at different stages of the life-cycle should not have a consistent effect on state level finances.

The second and third parts of this dissertation shift from an examination of the consequences of migration to studies of the determinants of domestic migration at the county level. A large literature has examined the various factors that play an important role in the decision to migrate. The second and third parts of this dissertation focus on location-specific factors that have received considerably less attention, but are prevalent and potentially important. In addition, these studies utilize spatial econometric techniques to account for spatial dependence of the migration measures. Application of these methods to large sample sizes, such as a county-level study, is rare.

The second part of the dissertation looks at possible effects of environmental contamination, in the form of toxic chemical releases, hazardous air pollutants, and hazardous waste sites, on county-level migration flows. Environmental contamination could substantially reduce the utility derived by residents and migrants, in much the same way that desirable amenities can increase utility. Reliable information on these sources of environmental contamination is available from the U.S. Environmental Protection Agency (EPA) through the Toxics Release Inventory (TRI), National Priorities List (NPL), and AirData air pollution database. Models of inmigration, outmigration, and net migration are estimated in an effort to accurately describe the effects of environmental contamination.

The third part of the dissertation can be seen as an extension of the second part. The focus is on a possible role for air pollution in the migration decision. Air quality has implications for the health and well-being of residents, particularly for sensitive groups, and can damage property. Unlike the measures examined in part two, air quality is highly regulated and the EPA produces a number of measures and warnings directed at increasing air quality awareness among the public. Two measures of emissions and two measures of ambient air quality are included in the empirical estimations. As with part two, inmigration, outmigration, and net migration are modeled. Considerable effort is given to interpret the estimation results and place them in the appropriate context.

1.2 Dissertation Outline

The next three chapters present three essays on consequences of migration at the state level and determinants of migration at the county level. The second chapter focuses on state outmigration and spending on public higher education and the third and fourth chapters focus on the role of environmental contamination and air quality in county migration flows. The fifth chapter is comprised of concluding remarks.

Chapter 2 considers the decline of state and local appropriations to public higher education in U.S. states. As state budgetary pressures increase, higher education is often the target of reduced government spending. This paper presents a theoretical model of the state appropriations decision for public higher education and shows that outmigration can be a determinant of the state level of appropriations. Testing this hypothesis empirically using a measure of total gross outmigration provides results similar to those reported in earlier studies. Using measures of gross outmigration disaggregated by age reveals that it is the mobility of certain age groups that are most important in the relationship with appropriations per student. An increased propensity of migration for individuals age 20-29 (“college graduates”) is associated with a reduction in appropriations per student, significant at the ten percent level. The estimated reduction in appropriations per student of $41 is the smallest of the age groups examined. The outmigration of individuals age 30 to 44, 45 to 64, and 65 to 74 leads to a more substantial reduction of appropriations to public higher education, lending support to the conclusion that a reduction in tax revenue is the main driving force behind lower state support. A one percentage point increase in outmigration for individuals age 45 to 64 is associated with a $141 reduction in state and local appropriations per student, and the same increase in outmigration for the 65 to 74 age group leads to $133 reduction. The estimate for the 45 to 64 age group is significant at the five percent level while the estimate for the 65 to 74 age group is significant at the ten percent level. A one percentage point increase in outmigration of individuals between 30 and 44 years of age is significant at the five percent level and is associated with a $69 fall in appropriations per student. The empirical results also show that state nonneed-based aid programs have led to increased appropriations per student. As these types of programs become more prevalent, examination of their impact on state finances becomes increasingly important.

Chapter 3 considers location-specific characteristics that have attracted limited attention in the migration literature. Unlike climate characteristics, pollution is a locational attribute that is dependent to some degree on state and local policies and the demands of the populace. Ample evidence exists that communities are informed and involved with respect to environmental contamination. A LexisNexis search of U.S. newspapers for mention of the U.S. Environmental Protection Agency (EPA) Toxics Release Inventory (TRI) within the last five years produces 564 citations. After a 2007 proposal to relax TRI reporting regulations on certain firms, 12 states brought a lawsuit against the federal government to retain the more stringent standards. This indicates that the TRI program had some measure of success given its intention of providing communities with information on toxic releases. In the context of this paper, community involvement is important because it shows that information on environmental contamination is available and is being utilized at the local level. Residents and potential migrants are likely to have an awareness of this issue.

The paper begins by focusing on toxic chemical releases to the air, water, land, and through underground injection. Using spatial econometric techniques, the conclusion is that on-site chemical releases have a statistically significant relationship with inmigration and net migration for the nonpoor and the poor. Effort is taken to accurately reflect the economic impacts that result. To further investigate the effects of environmental contamination, hazardous air pollutant (HAP) emissions and hazardous waste sites are incorporated into the empirical model. The finding is that HAPs and hazardous waste sites are statistically significant and are more likely to produce sizeable economic impacts. This is the first paper to use detailed toxic emissions data in a study of county migration. The results are of interest because they provide evidence that potential migrants have knowledge of, and respond to, environmental qualities other than climate.

Chapter 4 is related to the previous chapter but studies the effects of air pollution. Significant differences could exist compared with the previous findings on environmental contamination due to the availability of air quality information and strict government regulation. After controlling for spatial dependence, the conclusion is that criteria air pollutants do have a statistically significant impact on migration behavior when controlling for variation in economic opportunity and other location-specific characteristics. Measures of inmigration, outmigration, and net migration for nonpoor and poor migrants are employed in an effort to accurately describe the relationship. Increasing criteria air pollutant emissions decreases the rate of inmigration, outmigration, and net migration for the nonpoor. Similarly, for poor migrants the rate of inmigration and outmigration is reduced. This result holds when the measure of emissions is restricted to only point sources.

Chapter 2:

Interstate Migration and Spending on Public Higher Education

2.1. Introduction

For the 1999-00 school year, state and local appropriations accounted for 40% of public higher education current fund revenues for all 50 states while tuition and fee revenue accounted for 19% of current fund revenues (National Center for Education Statistics, *Digest for Education Statistics*). Justifications for higher education subsidies include developing an educated workforce, increasing the stock of human capital in the state, and maximizing possible external benefits of education. State and local appropriations to public higher education have declined recently in a majority of U.S. states. As state budgetary pressures increase, higher education is often the target of reduced government spending. Concomitantly, tuition and fees at public institutions of higher education have increased steadily as universities are forced to raise greater amounts of revenue to balance budgets.[1] The possible explanations for the decline in state and local appropriations are numerous and complex, involving political, social, and economic issues. The education and regional science literatures present evidence that outmigration may be negatively capitalized into state spending on public higher education by forward-looking legislators. The implications of such findings should be of particular interest to state level decision makers and individuals involved with public higher education. There is evidence that outmigration of graduates is observed by legislatures. Through 2005, 14 states have introduced scholarship programs aimed at retaining their most capable students for higher education and employment after graduation.

This paper presents a theoretical model of the state appropriations decision for public higher education and shows that outmigration can be a determinant of the state

[1] For a more complete empirical discussion of this literature refer to Koshal and Koshal (2000), Lowry (2001), and Rizzo and Ehrenberg (2002). Fethke (2005) provides a theoretical foundation for this relationship.

level of appropriations. Testing this hypothesis empirically using a measure of total gross outmigration provides results similar to those reported in earlier studies. Using measures of gross outmigration disaggregated by age reveals that it is the mobility of certain age groups that is of the greatest importance for determining appropriations per student. A one percentage point increase in outmigration of individuals age 20-29 ("college graduates") is associated with a $41 fall in appropriations per FTE student. A one percentage point increase in outmigration for individuals age 45 to 64 causes a $141 reduction in state and local appropriations, and the same increase in outmigration for the 65 to 74 age group leads to $133 reduction. The latter estimates are statistically significant at the five percent level. The empirical results also show that state nonneed-based aid programs lead to increased appropriations per student. As these types of programs become more prevalent, examination of their impact on state finances becomes increasingly important.

2.2 Literature Review

Weisbrod (1962, 1964) hypothesized that within a welfare-maximizing community rational voters discount the possibility of outmigration of educated students because the external benefits of education accrue outside the local jurisdiction. Specifically, communities which experience significant outmigration tend to underprovide primary and secondary public education expenditures in the absence of a system of intergovernmental transfers. In a later paper, the author tested this theory empirically using observations from the 48 contiguous states for the 1959-60 school year and concluded that states which had experienced net outmigration did spend less per pupil on primary and secondary public schooling (Weisbrod 1965). Net inmigration, a proxy for any possible spill-in effects, did not have a statistically significant effect on primary and secondary public education spending and therefore did not offset spillovers. The author argued that any costs or benefits from inmigration can be regarded as fixed because they are independent of community public expenditure decisions.

This result does not show that school expenditures fall to a suboptimal level, it only shows that expenditures are lower, and therefore it may be incorrect to conclude that there is underinvestment (Isserman 1976). If local factor prices are reduced as a result of outmigration, then an equivalent level of education can be provided at less expense to the community or jurisdiction. Additionally, Buchanan (1967) notes that parents with children who stand to gain from education subsidies are unlikely to allow persistent underinvestment. Outmigration suggests that individuals obtain a higher return on education in a different location. This higher return may induce higher private expenditure on education to compensate for the reduction in public spending. The current paper, following the others cited here, deals exclusively with public expenditures for higher education and the conclusions are relevant specifically for public expenditures, not total expenditures (both public and private).

Greene (1977) responded that local governments, not states, were the proper unit of analysis given that primary and secondary school expenditure is primarily a local decision. Furthermore he noted that gross migration flows, rather than net, were more effective at providing an accurate understanding of the relationship between migration and school expenditures. Using a sample of 53 school districts in New York for the 1971-72 school year, the author found qualitative support for Weisbrod's conclusion. However, the empirical model was sensitive to changes in specification and, in equations with greater explanatory power, the effects of both inmigration and outmigration were quantitatively small. Neither Holland (1974) nor Hadley (1985) was able to find evidence of negative capitalization of outmigration in spending for primary and secondary education. Hadley argued that the strong correlation between migration and per capita income in the 1950s made accurate interpretation difficult. After updating Weisbrod's estimation for the 1976-77 school year, the author found no support for the welfare maximization hypothesis and determined that income levels were of great importance in explaining expenditures.

Turning to public higher education inherently corrects for some difficulties mentioned above. The primary source of revenue for public institutions of higher education is state appropriations. Decisions on the size of appropriations take place at the state level thus justifying the use of state-level migration data. Clotfelter (1976) examined the effect of outmigration of recent college graduates on state and local support of public higher education and expenditures per capita by public institutions in all 50 states for 1970. The total expenditure measure was further disaggregated into student-related expenditures and general expenditures not related to student services. If institutions negatively capitalize outmigration of college graduates into state expenditures for education, it does not follow that this should affect more general expenditures unrelated to educating students. Outmigration is measured as an approximation of the probability that an individual moves out of a state for some period of time in their life.[2] While this provides a degree of age specificity within a single measure, it is not possible

[2] The measure is constructed using eight age groups, 1 (25-29), 2 (30-34), 3 (35-39), 4 (40-44), 5 (45-49), 6 (50-54), 7 (55-59), 8 (60-64), from the 1970 Census. The proportion of individuals in each age group who migrated from a state between 1965 and 1970 is then combined to create a single measure of the propensity of an individual to move outside the state over the entire range of ages. The assumption is that the migration behavior of public college and university graduates is comparable to others their age.

to observe the varying effects of outmigration on higher education finance at different stages of the life cycle. The author reports a negative and statistically significant relationship between propensity of outmigration and higher education instructional expenditures per capita for 1970. The elasticity of migration is -0.442 with respect to expenditures on instruction. Outmigration is not significantly related to the measures of total expenditures, general expenditures, or state and local spending on public higher education. The author also concluded that increased enrollment and higher per capita income led to larger per capita higher education appropriations. Possible spill-in effects were not tested under the assumption that spending on higher education represented a fixed benefit and would not influence migration decisions.

Using a three equation system to estimate state and local appropriations, tuition revenue, and outmigration, Strathman (1994) tested for both spillover and spillin effects of migration in the 48 contiguous U.S. states. Gross outmigration from 1985 to 1990 was shown to negatively affect state and local appropriations to public higher education for the 1989-90 school year. A one percentage point increase in outmigration resulted in a $103 reduction in appropriations per student. Inmigration did not have a statistically significant impact on appropriations. In this study, migration was not disaggregated by age, so it is difficult to conclude that it is a spillover of recent graduates that is negatively affecting state appropriations. This was first noted by Isserman (1976) in response to the Weisbrod (1965) findings. The magnitude of the loss to a state or community due to outmigration of the educated is closely related to the stage of the life cycle. Individuals who migrate soon after graduation have a different impact on state finances compared with individuals who migrate later in life. This is accounted for in the current analysis, unlike previous literature.

State support of public higher education may be justified by an increased likelihood of students remaining in the state after graduation and contributing to future tax revenues. Groen (2004) found modest support for the hypothesis that attending higher education in a state increases the probability of working in that state after graduation. He noted that the magnitude of the estimate is small and insufficient to justify broad-based merit scholarship programs at the state level. In a similar study, Bound et al. (2004) examined the link between state production of higher education and human capital stock in the state. The authors found that the production of higher education has very little effect on the number of college-educated workers in the state. Due to mobility, state investment in higher education has a limited ability to influence the stock of human capital within the state. Examining the social returns to higher education, Moretti (2004) concluded that cities with a higher share of college educated workers have higher wages for college graduates and less educated workers (high school dropouts and high school graduates). This is evidence of positive spillovers from higher education.

Using data from all 50 states for the years 1969 to 1994 Humphreys (2000) showed that state appropriations are sensitive to business cycle fluctuations. A similar relationship was found by Leslie and Ramey (1986) using regional level data for enrollment and appropriations and the NBER coincident index as a national measure of the business cycle. Humphreys (2000) used real appropriations at the state level and state real personal income per capita as a state specific measure of the business cycle. During a recession, income levels fall and the state collects less tax revenue resulting in lower state appropriations to public higher education. On average, a 1 percent change in real per capita income resulted in a 1.39 percent change in real appropriations per student. Higher education may also be treated as nonessential during a recession and may be faced with increased cuts in spending as state legislatures attempt to balance the budget. In a study on the University of Minnesota, Hoenack and Pierro (1990) report a positive but small income elasticity between tax revenues and appropriations suggesting that revenues and spending do move together. To the extent that outmigration of different ages affects (reduces) state revenue collection, this paper adds support to the conclusions of the previous studies.

2.3. Theoretical Model

The theoretical model presented here is adapted from the model developed by Fethke (2006) to analyze the relationship between resident and nonresident tuition. Migration effects are introduced and no distinction is made between resident and nonresident enrollment and tuition. The demand schedule for higher education is linear with $Q = a - bP$ where Q is enrollment and P is tuition. The parameter a represents the autonomous level of demand and is positive. The parameter b measures the responsiveness of enrollment to changes in tuition. University net revenue takes the form $R(P) = PQ + sQ - cQ = (P-c+s)Q$ where s is the subsidy (or appropriations) per student and c is the constant marginal cost of education. The university sets tuition in order to maximize university net revenue and student consumer surplus. The area under the demand function less tuition expenditures is the student consumer surplus. The university maximizes the following function:

$$G(P,s) = (P - c + s)(a - bP) + \frac{(a - bP)^2}{2b} \qquad (1)$$

The first term in equation (1) is net revenue and the second term represents student consumer surplus. The sequence of events in this model is the state legislature setting the subsidy per student and the university then determining tuition level. Fethke (2006) considers other possible arrangements. Solving backwards, maximization of equation (1) provides the following values for tuition and enrollment:

$$P^*(s) = c - s \tag{2}$$

$$Q^*(s) = a - b(c - s) \tag{3}$$

Tuition depends directly on the difference between costs and the per student subsidy. Enrollment increases with increased demand and increased subsidy per student and declines as costs increase.

Based on Fethke (2006), the legislature's indirect demand curve for enrollment is represented by $s = \alpha M/Q$ where M is the overall budget available to the legislature. The parameter α represents the weight the state legislature places on enrollment and takes values $0 \leq \alpha \leq 1$. αM is the proportion of the overall budget allocated to higher education expenditures. The surplus to legislature is given by the following function:

$$L(Q) = \alpha(\varphi)M(\gamma)\int_1^Q \frac{dx}{x} - sQ \tag{4}$$

This is the area under the demand function of the legislature less expenditures on subsidies[3]. The problem solved by the legislature in the first stage is:

$$L^*(s) = \max_s \alpha(\varphi)M(\gamma)\log Q^*(s) - sQ^* \tag{5}$$

where Q^* is taken from equation (3). The parameter φ represents the proportion of college graduates that leave the state soon after graduation. Previous work has shown

[3] Cobb-Douglas utility implies that the portion of the state budget spent on public higher education is fixed. This limitation is addressed by Fethke (2006). Important implications are not changed when this assumption is generalized.

that legislators may be less willing to subsidize higher education if a substantial proportion of graduates migrate out of the state. The expectation is that as φ increases the weight placed on enrollment (α) will decrease. The parameter γ represents outmigration of age groups other than recent graduates. This paper considers the possibility that migration at other stages of the life cycle could affect higher education finance. The overall budget is a function of γ because outmigration of different age groups could reduce available tax revenues. Therefore, a negative relationship is expected.

Solving the state legislature's problem for s gives the following function:

$$s^* = \frac{Q_c}{4b}\left(\sqrt{\frac{1+8\alpha(\varphi)M(\gamma)b}{Q_c^2}} - 3\right) \tag{6}$$

Here $Q_c \equiv a - bc$ is enrollment when there is no subsidy. The resulting subsidy is positive when the proportion of the budget allocated to higher education is greater than student surplus from unsubsidized enrollment, $\alpha(\varphi)M(\gamma) > \frac{Q_c^2}{b}$. Increased preference weight from the legislature and a larger state budget increase the likelihood of a positive subsidy. The preference weight is negatively related to outmigration of graduates and the overall budget is negatively related to outmigration of other age groups. Higher costs and reduced demand also lead to a positive subsidy. The signs of the comparative static results are presented below with the full results derived in the Appendix.

$$\frac{\partial s^*}{\partial a} < 0; \frac{\partial s^*}{\partial c} > 0; \frac{\partial s^*}{\partial M} > 0; \frac{\partial s^*}{\partial \alpha}\frac{\partial \alpha}{\partial \varphi} < 0; \frac{\partial s^*}{\partial M}\frac{\partial M}{\partial \gamma} < 0$$

Subsidy per student is increasing with respect to costs and overall budget and decreasing with respect to demand, outmigration of graduates, and outmigration of other age groups.

If autonomous demand is high and students are more willing to pay for education the optimal subsidy is reduced (Fethke 2006).

In the empirical model, income per capita, need-based and nonneed-based aid, and percent of state population that is elderly are considered demand factors. Income is also likely to be a major determinant of the overall state budget. Therefore, the expected sign is indeterminate initially. Costs are accounted for in the empirical model with three measures of enrollment in state higher education. The effects of outmigration are of the greatest interest for the current paper. Six different outmigration age groups are examined to allow for examine of varying effects of outmigration on higher education financing over the life cycle. Lagged tuition and fee revenue is an additional variable included in the empirical estimation. It is likely that legislators utilize information about the previous year's tuition when considering appropriations to public higher education. The expectation is that lagged tuition and fee revenue has a negative relationship with current appropriations.

2.4. Data and Methodology

Data for all two-year and four-year institutions of public higher education in the continental U.S. were collected for the 1989-90 and the 1999-00 school years and treated as a pooled cross-section for the econometric estimation. The restriction to these two years is a result of the availability of gross migration statistics, disaggregated by age, in Census years and allows for 96 observations. Initiation and budgeting of state funding for public higher education differs widely across states. The complexity of higher education financing is outlined by Humphreys (2000).[4] As he notes, funding formulas are a common feature in the budgeting process, but use by states has been sporadic. These formulas are aimed primarily at dispersing funds amongst institutions within a state rather than establishing the total size of appropriations. Furthermore, discretionary power is almost universally significant in determining final spending amounts. The focus of this paper is the relationship between state appropriations and outmigration. It is therefore appropriate to estimate the following reduced form equation, following Humphreys (2000), to obtain a clearer understanding of the determinants of public higher education funding:

$$APPR_{i,t} = y_t + \beta X_{i,t} + \varepsilon_{i,t} \tag{9}$$

$APPR_{i,t}$ is defined as state and local appropriations per full-time equivalent (FTE) student in state i for year t, y_t is a year dummy variable used to capture any time-specific effects. Appropriations are part of current fund revenues for institutions. $X_{i,t}$ is a vector of explanatory variables including a measure of gross migration over the five years preceding the appropriations decision. β is a vector of the coefficients to be estimated and $\varepsilon_{i,t}$ is an unobservable error term.

The migration statistics measure gross outmigration at the state level for the periods 1985 to 1990 and 1995 to 2000 and are disaggregated into six age groups loosely following the methodology of Plane and Heins (2003).[5] The authors examined 17 migration flow age profiles for 172 Bureau of Economic Analysis (BEA) Economic Areas and identified seven specific clusters of activity associated with life-cycle events.

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[4] Humphreys (2000) utilizes a report of The National Association of State Budget Officers (1996) which surveyed states on the appropriations process. The common thread among higher education funding in the various states is that a large degree of discretionary power is exercised in the budget process.

[5] Gross domestic migration figures are taken from the U.S. Census Bureau which calculates migration as the number of residents of a state in 2000 (1990) that resided in a different state in 1995 (1985).

Age profiles of six of these seven clusters are utilized in the current analysis. These are described as "college bound" (ages 10-19), "leaving college" (ages 20-29), "young families and the labor market" (ages 30-44), "families and the labor market" (ages 45-64), "retirement" (ages 65-74), and "elderly" (ages 75 and over).[6] Outmigration of the "leaving college" group is a proxy for the outmigration of public higher education graduates. It is assumed that graduates of public higher education exhibit migration behavior that is comparable to other individuals in the age group (Clotfelter 1976). Disaggregating the migration flows by age provides a more accurate picture of the consequences of migration and represents an important extension of previous work in the area. It is likely that more recent graduates represent a greater future benefit stream and therefore a greater potential loss for the state. It should also be true that outmigration at various stages of the life cycle will not have a consistent effect on state level finances (Isserman 1976). Gross migration flows for the 48 states are expressed as a percentage of the 1995 (1985) population in each age group.

The other explanatory variables include lagged tuition and fee revenue per FTE student, lagged total state personal income weighted by the population age 16 and over, FTE enrollment in public higher education per capita, graduate and professional enrollment as a percentage of total enrollment, percentage of students enrolled at private institutions, percent of the population age 65 and over, state awards per FTE student for need-based undergraduate scholarship and grant programs, and state awards per FTE student for nonneed-based undergraduate scholarship and grant programs. All education finance and enrollment data were taken from *Digest for Education Statistics* (National

[6] The seventh migration age profile not included here is as an "average" flow for each age group (Plane and Heins 2003).

Center for Education Statistics), personal income from U.S. Department of Commerce, Bureau of Economic Analysis (BEA), and migration and population data from the 1990 and 2000 *Census of Population* (U.S. Census Bureau). Data for need-based and nonneed-based aid by state were collected from the National Association of State Student Grant and Aid Programs (NASSGAP). All data are in 2000 U.S. dollars and the Higher Education Price Index (NCES) was used to adjust education finance data.

Lagged tuition and fee revenue is expected to have a negative relationship with appropriations as these are the two largest sources of public university revenue and can generally be viewed as substitutes.[7] Decreased appropriations necessitate higher tuition levels, and state legislators may be less willing to subsidize higher education in states with higher tuition levels. When making the appropriations decisions, legislators are likely to anticipate current tuition and fee revenues and a useful predictor of these revenues is previous tuition and fee revenues. Total state personal income weighted by the population age 16 and older is lagged one period. Due to tax collection and the budgetary process, current year revenues are not immediately available to the state legislature. Previous studies have found a positive relationship. States with higher personal income collect more tax revenues, have a larger overall budget, and a higher level of state and local appropriations.[8] Based on the theoretical model, income could have a negative effect on appropriations per student if it is a measure of autonomous demand for education. The two opposing effects result in the sign being indeterminate. Percentage of the population age 65 and over is also included, as this may reduce the

[7] For the 1999-00 school year, state and local appropriations accounted for 40% of public higher education current fund revenues for all states; tuition and fee revenue accounted for 19% of current fund revenues (National Center for Education Statistics, *Digest for Education Statistics*).
[8] In addition, this likely controls for some other demographic factors that could affect the level of appropriations. One example is the percentage of the population with a college degree.

willingness of state residents to support public higher education and lower the preference weight on higher education. The elderly could also be seen as competition for limited state resources (Poterba 1997, Tosun et al. 2007). In contrast, an older population may signal less demand for higher education and necessitate increased appropriations. As with income, two opposing effects mean the expectation of the sign cannot be determined.

Three measures of enrollment are included as explanatory variables. The first is enrollments per capita, which is intended to act as a measure of possible economies of scale in higher education.[9] If institutions are able to take advantage of increasing returns to scale in education, then additional enrollments will lower appropriations per FTE student. This could be of particular importance in a state with a large number of smaller decentralized institutions compared with a state having a small number of large universities. Secondly, a measure of graduate and professional enrollment is included. It is possible that a higher level of research activity leads to specialized programs, for the graduate and undergraduate levels, and necessitates or attracts increased funding from the state government. There may also be an underlying structural difference between institutions undertaking research and instruction compared with those focused solely on instruction. The final enrollment variable is the percentage of all higher education students enrolled in a private institution and is a measure of the availability and popularity of private higher education. In states where a high percentage of undergraduates attend private colleges, legislators may be less willing or have less need to provide financial support to public higher education. Initial expectations are that

[9] The literature for 4-year institutions contains mixed results on where universities operate along the average cost curve. Koshal and Koshal (1999) report no evidence of increasing returns to scale.

graduate enrollment has a positive effect on state and local appropriations while private enrollment has a negative effect.

The last two explanatory variables control for state aid to students and are disaggregated into need-based and nonneed-based (or merit) aid disbursements. Need-based aid is aimed at increasing access to higher education. Nonneed-based aid is perhaps the more interesting control given the rapid expansion of state broad-based merit scholarship programs. As of 2005, programs existed in fourteen states and are the major source of student aid in those states.[10] Requirements and value of awards vary between states with some providing full tuition scholarships to qualifying students at in-state public institutions (Heller 2004). The goal of such programs is consistent across states, provide an incentive for high-achieving high school students to remain in the state for higher education. However, this does not ensure that these students will remain in the state after graduation and could actually facilitate outmigration. The difficulty of some states to keep programs solvent due to greater than expected demand provides anecdotal evidence that these programs are being utilized by large numbers of students.[11] Both types of aid could lead to an increase in demand and appropriations. Fethke (2006) notes that an increase in demand should negatively affect appropriations, but he references federal loan programs. State aid could have different affects and may represent a larger legislative preference weight in states providing more aid to students. The expected sign on the two aid variables cannot be determined due to these conflicting effects.

[10] The leader in this movement was the Georgia HOPE scholarship introduced in 1993. In 2005, Alaska, Florida, Kentucky, Louisiana, Massachusetts, Michigan, Mississippi, Missouri, Nevada, New Mexico, South Carolina, Tennessee, and West Virginia fund similar programs. Requirements are generally based on one or more of the following: GPA, SAT/ACT score, standardized test score, or class rank (Heller 2004).

[11] Several states have tightened award criteria to combat rising costs.

Some research (Rubenstein and Scafidi 2002, Heller 2004) has shown that the bulk of merit-based scholarships are received by students who would attend college regardless of aid. Even if this is accepted, the variable still may have a significant impact on appropriations as more students decide to stay in-state for education. If it does not significantly affect the decision to attend college, it may affect the decision of where to attend college. With regard to merit aid, this could confound the expected sign on the coefficient if aid is flowing to students who have a relatively strong demand for higher education.

Table 2.1. Descriptive Statistics

Variable	Mean	Std. Dev.	Minimum	Maximum
State and local appropriations per FTE student ($)	7401.98	1491.35	3788.73	12109.96
Lag tuition and fee revenue per FTE student ($)	3414.17	1582.03	1378.71	11280.63
Lag income per capita ($)	32357.58	5046.09	22722.77	49373.65
FTE enrollment per capita	31.32	6.55	19.73	51.58
Graduate enrollment (%)	9.96	2.1	5.15	14.12
Private enrollment (%)	23.25	12.91	0.73	61.49
Need-based aid per FTE student ($)	259.05	292.01	0	1391.33
Nonneed-based aid per FTE student ($)	61.32	162.92	0	1339.42
Elderly population (%)	12.67	1.72	8.5	18.31
Outmigration (%)	10.12	3.04	5.79	23.81
Outmigration 10-19 (%)	9.84	3.26	5.13	24.42
Outmigration 20-29 (%)	18.60	6.07	8.71	41.47
Outmigration 30-44 (%)	12.77	4.31	6.11	32.83
Outmigration 45-64 (%)	7.18	2.27	3.79	15.89
Outmigration 65-74 (%)	4.97	1.86	2.56	12.55
Outmigration 75+ (%)	4.79	1.87	2.51	12.68

In an effort to control for possible political economy effects, a dummy variable for state gubernatorial elections was created. Three separate variables were tried for elections that occurred three years, two years, and one year prior to the appropriations observations. During a campaign, gubernatorial candidates may propose an increase in spending on education or they may propose a cut in funding due to budget concerns. A dummy variable was also created to identify states with a Democratic governor and a Democratic majority in both houses of the state legislature. All variables were statistically insignificant and did not improve the explanatory power of the regression equations, for this reason they were excluded from the estimation. Descriptive statistics for all variables included in the empirical estimations can be found in Table 2.1.

2.5. Empirical Results

The initial step is to estimate an equation using a measure of outmigration that is not age specific, similar to previous studies. Results are reported in Table 2.2. Gross outmigration as a percentage of population is negative and statistically significant at the five percent level. A one percentage point increase in outmigration leads to an approximate reduction in state and local appropriations per student of $91. This is comparable to the finding of Strathman (1994) and supports other work that has reported on this consequence of outmigration. The contribution of the current paper is to disaggregate the measure of outmigration by age to gain a clearer understanding of the relationship between migration and appropriations to public higher education.

Table 2.3 shows estimation results with one set of results for each of the six migration age groups. Each outmigration age group is estimated separately while keeping all other explanatory variables and the dependent variable constant. Estimating the effects of the different age groups in separate regressions allows for examination of the impact each group has on state and local appropriations per FTE student. In addition, the rates of outmigration for the different age groups are highly correlated. The Breusch-

Table 2.2. Dependent Variable: State and Local Appropriations per FTE (2000 dollars)

Variable		
Year		527.672*
		(1.85)
Lag tuition and fee revenue		-0.521***
		(5.83)
Lag income per capita		0.076**
		(2.44)
FTE enrollment per capita		-37.032
		(1.48)
Graduate enrollment		74.182
		(1.35)
Private enrollment		-28.967**
		(2.09)
Need-based aid		0.828
		(1.53)
Nonneed-based aid		2.229***
		(2.94)
Elderly population		-90.284
		(1.29)
Outmigration		-91.458**
		(2.11)
R^2	0.52	
F-test (10, 85)	9.22***	
N	96	

Absolute value of t-statistics shown in parentheses. *, **, *** denotes 10%, 5%, 1% level of significance respectively.

Pagan (1979) test for heteroskedasticity was performed on each specification. Based on the results, heteroskedasticity is not a problem in any of the specifications. To test for possible multicollinearity, variance inflation factors (VIF) were calculated for each specification. The largest VIF corresponds to the measure of college private enrollment and has a value of 2.88. The mean VIF for the six equations ranges 1.67 to 1.75. Multicollinearity is not a concern in this data.

Outmigration of the 10 to 19 age group ("going to college") is negative and statistically significant at the ten percent level. The migration behavior of this group is highly, if not completely, dependent on the choices of parents and guardians. These individuals do not represent a benefit spillover in regards to public higher education. The behavior of this group is included in the aggregated measure of outmigration estimated in Table 2.2 and in some previous literature, although their behavior has little relevance to the question being asked.

An important variable for this paper is the outmigration of the group age 20 to 29, a proxy for the outmigration of students soon after graduation from higher education. It is this group that constitutes the greatest loss of future benefits to a state, as migration immediately following graduation implies that none of the external benefits of education accrue to the state that provided the education. The welfare maximization literature has hypothesized that state legislators react to the outmigration of graduates by reducing appropriations to public higher education. The results show that a one percentage point increase in 20 to 29 outmigration ("leaving college") is associated with a nearly $41 decrease in appropriations per FTE student. This result is statistically significant at the ten percent level. A reduction of $41 represents a 0.56 percent fall in appropriations per FTE student evaluated at the mean ($7,402). The elasticity of appropriations per student, with respect to the parameter estimate and the means of the variables, is -0.10.

The outmigration of individuals age 30 to 44 and age 45 to 64 is negative and statistically significant at the five percent level, while outmigration for the 65 to 74 age groups is negative and significant at the ten percent level. A one percentage point increase in outmigration of 30 to 44 year olds ("young families and the labor market") leads to a nearly $69 reduction in state and local appropriations per student, a drop of 0.93 percent at the mean. The coefficient estimate for outmigration of the 30 to 44 age groups is not statistically different than the estimate for the outmigration of the 20 to 29 age group. An equivalent one percentage point increase in outmigration for the 45 to 64 age group ("families and the labor market") is associated with a decrease of $141, 1.9 percent, and for the 65 to 74 age group a reduction of $133, 1.8 percent. The coefficient estimate for the 45 to 64 age is statistically larger than the estimate for the 20 to 29 age group at the 10 percent level of significance. The coefficient estimate for the 65 to 74 age group is not statistically different than the estimate for the 20 to 29 age group. The elasticity of appropriations per student with respect to outmigration of those in the 30 to 44 age group is -0.12 evaluated at the mean. The elasticity for the 45 to 64 age group is -0.14 and for the 65 to 74 age group the elasticity is -0.09. The mean rate of outmigration for the 20 to 29 age group is 18.6 percent. This mean falls to 12.8 percent for the 30 to 44 age group, 7.2 percent for the 45 to 64 age group, and 5.0 for the 65 to 74 age group. Outmigration of the "elderly", those over age 75, does not have a statistically significant relationship with state and local appropriations.

Outmigration at different stages of the life cycle does not have a consistent effect on the financing of public higher education. Individuals in the latter three age groups are, on average, more established in the work force. They enjoy greater earning potential than more recent graduates, have more accumulated wealth, and therefore contribute more tax revenue to the state. This contribution to state tax revenues primarily consists of various sales taxes and individual income taxes. According to the 2002 *Census of Governments*, 36.1 percent of general revenue from own sources came from sales taxes, including

Table 2.3. Dependent Variable: State and Local Appropriations per FTE student (2000 dollars)

Variable	10-19	20-29	30-44	45-64	65-74	75+
Year	533.825*	704.122**	430.638	677.596**	497.220*	640.554**
	(1.85)	(2.49)	(1.43)	(2.45)	(1.69)	(2.25)
Lag tuition and fee revenue	-0.522***	-0.510***	-0.544***	-0.517***	-0.504***	-0.518***
	(5.81)	(5.63)	(6.09)	(5.84)	(5.52)	(5.63)
Lag income per capita	0.078**	0.066**	0.072**	0.089**	0.091**	0.072**
	(2.46)	(2.14)	(2.34)	(2.79)	(2.66)	(2.27)
FTE enrollment per capita	-43.288*	-35.623	-33.231	-43.044*	-57.412**	-58.338**
	(1.76)	(1.39)	(1.29)	(1.80)	(2.37)	(2.34)
Graduate enrollment	75.667	71.461	77.501	69.071	58.286	62.316
	(1.37)	(1.29)	(1.40)	(1.27)	(1.05)	(1.11)
Private enrollment	-31.706**	-25.712*	-27.421**	-31.515**	-33.619**	-33.459**
	(2.25)	(1.84)	(1.99)	(2.28)	(2.35)	(2.23)
Need-based aid	0.837	0.842	0.863	0.801	1.009*	0.993*
	(1.53)	(1.55)	(1.60)	(1.50)	(1.89)	(1.83)
Nonneed-based aid	2.250***	2.141***	2.334***	2.136***	2.132***	2.277***
	(2.95)	(2.78)	(3.08)	(2.83)	(2.76)	(2.94)
Elderly population	-77.229	-63.365	-92.146	-111.679	-103.049	-75.431
	(1.10)	(0.90)	(1.31)	(1.58)	(1.43)	(1.06)
Outmigration	-73.989*	-40.695*	-68.651**	-141.439**	-133.405*	-73.328
	(1.83)	(1.86)	(2.04)	(2.48)	(1.79)	(1.09)
R^2	0.51	0.52	0.52	0.53	0.51	0.50
F-test (10, 85)	9.00***	9.02***	9.16***	9.56***	8.97***	8.57***
N	96	96	96	96	96	96

Absolute value of t-statistics shown in parentheses. *, **, *** denotes 10%, 5%, 1% level of significance respectively.

general sales and excise taxes, for all 50 states in 2001-02. Individual income taxes accounted for another 25.5 percent of general revenue from own sources in 2001-02. These are the two largest sources of revenue at the state level. Although local governments spend considerably less than state governments on higher education, they are included in the appropriations measure used here. Property taxes accounted for 45.1 percent of general revenue from own sources for all local governments in 2001-02. Sales taxes contributed 10.3 percent to general revenue.[12] Increased outmigration of groups that earn the highest income and spend more on average, age groups 30 to 44, 45 to 64, and to a lesser extent 65 to 74, leads to a fall in tax revenues collected.

The ensuing reduction in state and local appropriations could be due to general reduction in spending on all government functions or higher education experiencing a disproportionate cut in appropriations. This suggests a more direct effect of outmigration on public higher education financing and the overall budget. To the degree that outmigration is a consequence of a recessionary period, the findings lend support to Humphreys (2000). Outmigration is associated with decreased public higher education spending levels, but the results suggest that interjurisdictional spillovers are not the sole driving force. Earlier work on this subject, which utilized total outmigration as a proxy, was unable to present this clearer picture of the relationship between outmigration and appropriations due to a lack of migration data disaggregated by age.

Some of the general findings consistent across all specifications include the fact that lagged tuition and fee revenue is negative, as expected, and consistently significant at the one percent level. Previous tuition and fee revenue is important in explaining the

[12] The calculations are based on information taken from Table 1, State and Local Government Finances by Level of Government and by State: 2001-02 from the 2002 Census of Government. This can be found on the Census website at: http://www.census.gov/govs/www/estimate02.html.

current level of appropriations. Lagged total state personal income weighted by the population age 16 and over is positively related to state and local appropriations and is statistically significant at the five percent level in all of the specifications. Since the size of the population age 16 and under varies between states, weighting state personal income this way is a more appropriate measure than per capita personal income for this analysis. In line with previous work, the estimation shows that states with higher personal income provide higher appropriations per FTE student. This is likely a result of more tax revenue and a larger budget for all state programs and relates to the outmigration results discussed above. The positive effect of income on the overall state budget is more important than its ability to increase demand for education and reduce the need for appropriations. The relationship between higher education and income may also indicate that states with higher personal income have a greater proportion of college educated individuals who are more willing to finance higher education. The measure of the elderly population in each state is consistently insignificant. This result is not surprising based on the conflicting effects related to having an older population discussed above.

Enrollment per capita is statistically significant at the five percent level in the final two specifications in Table 2.3. For the two academic years examined here, it is difficult to make a determination on the ability of public colleges and universities to take advantage of economies of scale. If economies of scale do exist, the variable coefficient would be negative, as it is in all specifications, implying that admitting a larger number of students decreases appropriations per FTE student. The parameter estimate for percentage of graduate students is statistically insignificant for all specifications. The final enrollment variable, percentage of students enrolled at private institutions, is negative and significantly different from zero in all specifications. A one percentage point increase in private enrollment will lead to an approximate $30 reduction in state and local appropriations per FTE student. This shows that legislators in states where a significant proportion of students attend private colleges and universities are less willing, or find it unnecessary, to support public higher education as strongly. This also highlights regional differences in education funding patterns given the prevalence of private colleges in the Northeast and the reliance on public education in the West.

State need-based aid per student is positive and statistically significant in two specifications and nearly significant at the ten percent level in all others. An increase in need-based aid may lead to an increase in appropriations but strong conclusions cannot be drawn from these results. Nonneed-based aid is positively correlated with appropriations in all specifications at the one percent level and the magnitude of the coefficient is more than twice that of need-based aid. A one dollar increase in state nonneed-based aid results in a more than two dollar increase in state and local appropriations, however nonneed-based aid is still relatively low for this time period with a mean of $61.32 per student. The result is of interest as broad-based merit scholarship programs are growing in prevalence. In most states, these programs are funded through non-traditional revenue sources such as lottery revenues and are intended to supplement, not supplant, existing higher education funding.[13] The positive sign of the coefficient is evidence that this form of student aid has not substituted for appropriations to institutions. Quite the opposite, it seems that these programs have necessitated greater appropriations

[13] Of the fourteen states mentioned earlier with such programs, seven use lottery funding, four use general revenues, two use funding from tobacco settlements, and Alaska uses revenue from the sale and lease of land (Heller 2004).

in states with such programs. This is more than likely a direct result of the popularity these programs have experienced as more students make the decision to attend in-state universities. Dynarski (2002) reports analogous findings that broad-based merit programs result in a five to seven percentage point increase in the probability that college-age individuals will attend higher education. It could also be that states with merit aid programs place greater importance on higher education. Finally, it should be noted that this is not evidence of success if the ultimate goal of broad-based merit scholarship programs is to retain graduates.

2.6. Conclusion and Discussion

This paper has provided insight into a locational consequence of outmigration by focusing on state and local appropriations to public institutions of higher education. First a theoretical model was derived based on the interaction of a university governing board and a state legislature. Appropriations were shown to be a function of the propensity of outmigration. An empirical test was then carried out to determine if mobility at different stages of the life cycle significantly affects appropriations to public higher education. Previous studies have found a statistically significant negative relationship between outmigration and state and local appropriations to public higher education. Using a pooled cross-section for the 1989-90 and 1999-00 school years and controlling for other factors that determine spending, a comparable result is found. However, after gross outmigration flows were disaggregated by age a clearer picture emerged. Outmigration among the youngest age group is statistically significant, but this migration behavior is almost surely determined by parents, guardians, or college choice and these individuals would have yet to complete higher education. Therefore, this result does little to answer the question being asked. The estimates for outmigration of the “elderly” (age 75 and over) are not statistically significant.

A percentage point increase in outmigration among the “leaving college” age group (age 20-29) is associated with a $41 drop in state and local appropriations per student, significant at the ten percent level. However, the outmigration of the “young families and the labor market” (age 30-44) and “families and the labor market” (age 45-64) groups are associated with reductions of $69 and $141. Both results are statistically significant at the five percent level. The “retirement” (age 65-74) group also has a significant negative relationship with appropriations at the ten percent level. The results suggest a tax revenue link to the observed reduction in appropriations, rather than only a response by legislators to the propensity of recent graduates to migrate out of state. Outmigration at different stages of the life cycle has considerably different effects on public higher education financing. In addition, the paper concludes that broad-based state merit scholarship programs have led to higher appropriations per student. Such programs provide a very strong incentive for students to attend higher education in-state and necessitate increased spending to balance demand. This result is of interest as expansion of these relatively new programs continues and evaluation progresses.

Chapter 3:

Environmental Contamination and Migration Behavior in U.S. Counties

3.1 Introduction

The quality of the surrounding environment in any location impacts the resulting enjoyment gained by residents and impacts their health and well being both directly and indirectly. Location characteristics play an important role in the migration decisions of households. Climate and environmental quality, among other things, directly impact the utility derived from residing in a particular area. Regional and local climate conditions are relatively stable and the effects on migration patterns have received much attention. In contrast, only a small number of empirical studies have focused on environmental contamination and the resulting impacts on population flows (Rupashinga and Goetz 2004, Cebula 2005, 2006). Pollution adversely affects wildlife and natural habitats and alters local environmental conditions. Environmental contamination also has serious consequences for human health and development. As a result, utility derived by residents and potential migrants can be reduced significantly when environmental conditions suffer. Thus, it seems likely that contamination plays a role in many household location decisions.

Unlike climate characteristics, pollution is a locational attribute that is dependent to some degree on state and local policies and the demands of the populace. Ample evidence exists that communities are informed and involved with respect to environmental contamination. A LexisNexis search of U.S. newspapers for mention of the U.S. Environmental Protection Agency (EPA) Toxics Release Inventory (TRI) within the last five years produces 564 citations. A selection of newspaper stories from the last two years alone originate from Seattle, WA (Martin 2008), San Francisco, CA (Taugher 2008), Portland, ME (Richardson 2006), Boston, MA (Hurst 2007), Hartford, CT

(Funkhouser 2008), and Columbus, OH (Mayhood 2007). After a 2007 proposal to relax TRI reporting regulations on certain firms, 12 states brought a lawsuit against the federal government to retain the more stringent standards (DePalma 2007). This also indicates that the TRI program had some measure of success given its intention of providing communities with information on toxic releases. In the context of this paper, community involvement is important because it shows that information on environmental contamination is available and is being utilized at the local level. Residents and potential migrants are likely to have an awareness of this issue.

A large literature within regional science focuses on the migration decisions of rational individuals. The examination of pollution or environmental degradation is interesting because these less traditional location characteristics can be impacted by local decision making. Specifically, the current paper focuses on toxic chemical releases to the air, water, land, and through underground injection. Using spatial econometric techniques, the conclusion is that on-site chemical releases have a statistically significant relationship with inmigration and net migration for the nonpoor and the poor. Effort is taken to accurately reflect the economic impacts that result. To further investigate the effects of environmental contamination, hazardous air pollutant (HAP) emissions and hazardous waste sites are incorporated into the empirical model. The finding is that HAPs and hazardous waste sites are statistically significant and are more likely to produce sizeable economic impacts. This is the first paper to use detailed toxic emissions data in a study of county migration. The results are of interest because they provide evidence that potential migrants have knowledge of, and respond to, environmental qualities other than climate.

3.2 Literature Review

An extensive literature exists within regional economics that examines the various determinants of domestic migration. Models of migration behavior can be classified as disequilibrium or equilibrium. Disequilibrium models argue that spatial differences in utility are the driving force behind individual or household migration. Utility differences arise from variations in economic opportunity which may be represented by expected income, unemployment, or an increase in employment opportunities. These models assume that spatial differences persist, that interregional labor markets do not adjust quickly, and therefore households move towards areas of higher expected utility. The prominence of employment factors in the migration decision originates from the view of Sjaastad (1962) that migration is an investment in human capital. Disequilibrium models have been studied by Greenwood and Hunt (1984), Greenwood, Hunt, and McDowell (1986) and Greenwood and Hunt (1989). Disequilibrium type models dominated early work attempting to explain domestic migration (Greenwood 1985).

Equilibrium models argue that spatial variation in economic opportunities is more accurately seen as compensating differentials that correspond to differences in location amenities. Wages are necessarily higher, and rents lower, in undesirable locations while workers are willing to accept lower wages and pay higher rents to live in areas with desirable amenities. In these models, land and labor markets are considered efficient and migration assures that any spatial variation in utility does not persist. As a result, equilibrium compensating differentials are quickly restored. Persistent migration results from changes in demand for consumption of location-specific amenities or from changes in the supply of amenities at various locations. Demand for amenities could change over the life-cycle or as income levels rise under the assumption that amenities are normal goods. Non-traded location-specific goods take two forms, local government spending and taxation (Tiebout 1956) and a more general amenity bundle that includes factors such as climate and recreation. Economic opportunity, public goods provision, and location amenities are all addressed in the current model.[14]

The empirical work in equilibrium settings has focused on the importance of amenities and disamenities in the migration decision. Graves (1980) examines the relationship between climate and economic opportunity with data from 49 SMSAs between 1965 and 1970 and concludes that observed differences in income and unemployment are the compensation necessary for spatial utility indifference. Investigating this relationship for whites and non-whites, Graves (1979) finds that whites are generally more concerned with unemployment and climate when deciding to migrate while non-whites are concerned with income differentials and are affected very little by climate considerations. According to Linneman and Graves (1983), site characteristics are important in equilibrium and disequilibrium settings and the influence tends to grow stronger over the life-cycle. In a larger setting, regional economic development can be dependent on the ability of location-specific amenities to attract potential skilled migrants (Knapp and Graves 1989).

Clark and Hunter (1992) examine net migration of white males at the county level for the period 1970 to 1980. The authors incorporate a large number of explanatory variables to describe economic opportunity, location amenities, and fiscal factors in each county. Variables representing all three factors prove to be important, with economic opportunity dominating during working years and amenities gaining importance for older migrants. As expected, high income taxes are a deterrent during working years while

[14] Hunt (1993) provides an overview of disequilibrium and equilibrium models.

older migrants move to avoid inheritance and estate taxes. Related to this, Conway and Houtenville (1998, 2001) focus on elderly migration primarily because this group is not constrained by a reliance on employment income. It is hypothesized that location-specific characteristics are of greater importance to the elderly for this reason. Using data from the 1990 Census on state gross migration flows of individuals 65 and older, the authors conclude that this age group is concerned with climate and government fiscal policies. A theoretical explanation of elderly migration is provided by Graves and Knapp (1988).

Some of the ideas in this paper follow the recent work of Cebula (2005). The author investigates determinants of gross state inmigration for the period 1999 to 2002. He includes a variable for expected income and variables describing annual sunshine, January temperature, crime, and prevalence of state parks. The variable of interest measures the quantity of hazardous waste sites. It is specified as the number of hazardous waste sites per 1,000 square miles within the state and has a negative effect on state inmigration, significant at the one percent level. In a similar study, Cebula (2006) employs more recent data to examine net state inmigration rates from 2000 to 2004. The empirical model contains a variable for hazardous waste sites and a variable for toxic chemical releases. These are specified as the percent distribution of hazardous waste sites in the state on the National Priorities List (NPL) and toxic chemical releases in pounds per person for 2000, respectively. Both variables have negative and statistically significant coefficients, meaning that both discourage inmigration to a state. While these papers provide insight into the relationship between environmental quality and migration, a smaller unit of analysis is desirable. The presence of superfund sites or the intensity of toxic chemicals is unlikely to be consistent across any state. Environmental conditions often vary substantially.

This problem is addressed by Rupashingha and Goetz (2004) as they include cancer risk, presence of superfund sites, and EPA hazard ranking score in a general spatial model estimation of county-level net migration for the time period 1990 to 1999. Cancer risk is measured using an index compiled by Environmental Defense (ED) from 1990 EPA emissions data detailing an individual's increased risk of cancer based on long-term exposure to 148 hazardous air pollutants. The hazard ranking system is a precursor to inclusion on the National Priorities List and serves as an alternate measure of the effect of hazardous waste sites. The authors conclude that all three measures of health risk factors and environmental quality deter net inmigration at the county level. They also note that the costs of obtaining high-quality environmental information are continuously decreasing.

A drawback of the papers addressed in this review is their focus on net migration or single directional state inmigration. Rogers (1990) formalizes the limitations and bias of uniregional net migration measures and cautions against the interpretation of results from models attempting to explain net migration. Measures of inmigration and outmigration are preferable and more accurately depict the migration process while not being confounded by population stock levels. This paper is an attempt to describe the affects of toxic chemical releases and hazardous air pollutants, or more generally environmental contamination, on migration patterns. Measures of inmigration, outmigration, and net migration are utilized, although affects on inmigration and outmigration receive increased attention.

3.3 Data and Methodology

3.3.1 Data

The migration model in this paper parallels that used by Clark and Hunter (1992) and is standard in the migration literature. Migrants attempt to maximize utility when choosing between alternate locations. Potential migrants make the decision to move to or from a county when the expected utility at the destination exceeds the utility at their current location. The decision is based on the goods provided at each location, the cost of these goods, and the economic opportunities available. Migrants consume private goods and location-specific goods. In order to consume more (or less) of a locational characteristic it is necessary to migrate. This paper focuses on non-traded location-specific goods. The theoretical model of migration behavior in county i takes the following form:

$$\mathbf{MIG_i = f(ECONOPP, AMENITIES, TAXEXP)}$$

where migration is dependent upon economic opportunities (**ECONOPP**), the combination of amenities and disamenities (**AMENITIES**), and government taxation and expenditure on public goods (**TAXEXP**). The empirical model investigates the distinction between poor migrants and nonpoor migrants. Level of income could result in a systematic difference in migration behavior. Policies and characteristics that are attractive to poor migrants may be deterrents to the nonpoor, and vice versa. Lower income individuals are less able to incur the costs of relocation and could find a larger quantity of affordable housing in locations that would be undesirable to the nonpoor. Assuming environmental quality is a normal good, individuals with higher income should display an increased affinity for areas with preferable climate conditions. Nord (1998) provides a comprehensive look at differences in migration behavior between counties based on income level. The author finds that the poor are as mobile as the nonpoor but differences in response to county characteristics lead to spatial concentrations of poor individuals.

Equilibrium effects in a migration model explain relocation as a response to changes in demand for or supply of location-specific amenities. This paper determines if differences in income translate to differences in demand for clean air and environment. The possibility of a change in the supply of a location-specific amenity is particularly interesting with respect to air pollution and environmental degradation. Unlike climate, the supply of clean air, water, and soil at any location can change noticeably over a relatively short time period. It is just as likely that the dispersion of information on air and water quality provides residents and potential migrants with knowledge of a previously unknown or ignored environmental characteristic. Even if the supply of clean air and water does not change drastically (or at all), innovative information could effectively change what residents and migrants see as the supply of clean air and water at a location. As knowledge of the presence of toxic pollutants and their possible health effects deepens, greater migration responses could result. The intent of the many programs at the U.S. EPA is to provide information on environmental quality for consideration by communities and individuals. More and better information could be manifested in household location decisions.

Specific dependent and explanatory variables employed to measure migration behavior and county characteristics are described in the table below. Explanatory variables are measures at the beginning of the migration period or as near as possible.

Table 3.1. Data Description and Sources		
Variable	**Description**	**Source**
Dependent Variables		
Nonpoor inmigration	Nonpoor inmigration as a percent of 1995 population above poverty line, 1995-2000	U.S. Census Bureau
Nonpoor outmigration	Nonpoor outmigration as a percent of 1995 population above poverty line, 1995-2000	U.S. Census Bureau
Nonpoor net migration	Nonpoor net migration as a percent of 1995 population above poverty line, 1995-2000	U.S. Census Bureau
Poor inmigration	Poor inmigration as a percent of 1995 population below poverty line, 1995-2000	U.S. Census Bureau
Poor outmigration	Poor outmigration as a percent of 1995 population below poverty line, 1995-2000	U.S. Census Bureau
Poor net migration	Poor net migration as a percent of 1995 population below poverty line, 1995-2000	U.S. Census Bureau
Explanatory Variables		
On-site releases	Total on-site toxic chemical releases in thousands of pounds, 1995	U.S. EPA, TRI
Air	Total air emissions (fugitive and point sources) in thousands of pounds, 1995	U.S. EPA, TRI
Land	Releases to land within boundaries of facility in thousands of pounds, 1995	U.S. EPA, TRI
Underground	Underground injection of fluids into wells in thousands of pounds, 1995	U.S. EPA, TRI
Water	Surface water discharges in thousands of pounds, 1995	U.S. EPA, TRI
HAP	Thousands of pounds of all 188 hazardous air pollutants classified by EPA emitted, 1999	U.S. EPA, AirData
NPL	Number of hazardous waste sites in the county on the National Priorities List, 1995	U.S. EPA
Income	Per capita personal income, 1995	BEA REIS
Employment	Percentage growth in total employment, 1990-1995	BEA REIS
Median value	Median value of owner-occupied housing, average of 1990 and 2000 values	U.S. Census Bureau
Density	County population per square mile	Computed
Density Squared	County population density squared	Computed
Crime	Number of violent crimes and property crimes per 1000 population, 1995	USA Counties
January temp.	Average January temperature	NORSIS
July temp.	Average July temperature	NORSIS
January sun	Percent of possible January sunshine	NORSIS
July humidity	Average July humidity	NORSIS
Coastal	Coastal county=1, else=0	NORSIS

Health	County health and hospitals expenditures per capita, 1997	USA Counties
Welfare	County public welfare expenditures per capita, 1997	USA Counties
Education	County education expenditures per student, 1997	USA Counties
Taxes	Total county taxes per capita, 1997	USA Counties
Primary	Proportion of total private non-farm employment in agricultural services, fishing, forestry, and mining, 1995	BEA REIS
Manufacturing	Proportion of total private non-farm employment in manufacturing, 1995	BEA REIS
Construction	Proportion of total private non-farm employment in construction, 1995	BEA REIS
Trade	Proportion of total private non-farm employment in wholesale and retail trade, 1995	BEA REIS
Transport	Proportion of total private non-farm employment in transportation, 1995	BEA REIS
FIRE	Proportion of total private non-farm employment in financial services, insurance, and real estate, 1995	BEA REIS
Metro	Metropolitan county=1, else=0	USDA ERS
Rural	Nonmetropolitan county not adjacent to a metropolitan county=1, else=0	USDA ERS
College pop.	Percent of total county population between 18 and 24 years of age, 1995	U.S. Census Bureau
1990 inmigration	Inmigration from 1985 to 1990 as a percent of county population in 1985	U.S. Census Bureau

BEA REIS, Bureau of Economic Analysis Regional Economic Information System; NORSIS, National Outdoor Recreation Supply Information System; USDA ERS, Unites States Department of Agriculture Economic Research Service; U.S. EPA TRI, Environmental Protection Agency Toxics Release Inventory

The disaggregation of migration flows by poverty status reveals a peculiar pattern of poor migration for multiple counties. Counties containing a college or university experience very elevated rates of poor inmigration. In the migration statistics obtained from the U.S. Census Bureau, many college students are considered poor inmigrants and therefore the influx of poor migrants is excessively large compared with the poor population in the county. This leads to very large inmigration rates, exceeding 100 percent, in some counties. The higher rate of poor inmigration is most noticeable for counties with large universities that do not also contain a large metropolitan area. However, the effect can be large in sparsely populated counties with a small number of poor residents that contain a smaller college or university branch campus. For instance, in Adair County, Missouri in 1999 (when poverty status is determined for Census migration purposes) 2,507 residents are classified as poor and 18,909 residents are classified as nonpoor. The campus of Truman State University is located in Adair County and currently has an enrollment of approximately 5,600 students (TSU 2007). The effect of the college student population gives Adair County a poor inmigration rate of 122 percent for 2000. Because inmigration is used in the calculation of net migration, these rates are also inflated in the same counties. Adair County has a poor net migration rate of 89 percent. There is an important but less obvious effect on outmigration of the nonpoor from these same counties because poverty status is determined in 1999. Students who have graduated college or completed graduate school, gained employment, and migrated between 1995 and 1999 are classified as nonpoor and could report their residence five years ago as the university or college town. The result is an inflated nonpoor outmigration rate. Percent of county population between ages 18 and 24 in 1995 is included in each model specification to account for the effects of college populations in the county migration statistics.

Income, median housing value, and employment growth are included to control for economic opportunities in each county. Including measures of income and housing value also ensures that any capitalization of amenities into wages or rents is captured in the model. The percent of total employment in six industry sectors is included to control for the county industrial structure. The climate variables include average January and

July temperature, percent of possible sunshine in January, and average July humidity. Population density, population density squared, and the crime rate are additional measures of location amenities. Dummy variables are used for metropolitan counties, rural counties that are not adjacent to metropolitan counties, and coastal counties. Local government spending is taken into account by including expenditures on education, welfare, and health and hospitals. Taxation is measured as total county taxes per capita. Previous inmigration is included in the outmigration specifications because individuals who have migrated previously are more likely to move again.

In 1986 the Emergency Planning and Community Right-to-Know Act (EPCRA) was passed to provide communities with information on hazardous chemicals in their local area. Sections 311 and 312 of this act require that businesses provide information to state and local governments about on-site chemicals. Section 313 of the act requires EPA and state governments to make information about releases and transfers of chemicals publicly available through the Toxics Release Inventory (TRI). Information included in the TRI is available from several sources within EPA and is reported by other organizations as well. The TRI officially started in 1988 and currently contains data on approximately 650 chemicals or chemical groups released from a large number of industries[15]. The threshold for reporting to the TRI is 10,000 pounds per year for a regulated chemical used at a facility and 25,000 pounds per year for a regulated chemical processed or manufactured at a facility (EPA 2008). Data from the TRI is of particular interest because the stated goal of the program is to provide information about hazardous chemicals to individuals and communities for decision-making purposes. Environmental information is generally not easily accessible compared with other location characteristics

[15] The full list of chemicals included in the TRI is available at: http://www.epa.gov/tri/chemical/index.htm.

such as climate. Although releases may not be readily observable, the TRI program does ensure public access to a comprehensive database.

The Clear Air Act of 1990 identified 189 hazardous air pollutants (HAP), sometimes called toxic air pollutants or air toxics, which were known or expected to cause significant health problems. Measurements and standards on the ambient concentrations of these pollutants are not mandated by the Clean Air Act. Instead, EPA is tasked with limiting emissions and preventing concentrations from reaching dangerous levels. There are currently 188 identified hazardous air pollutants (EPA 2007a).

Emissions primarily originate from stationary sources or mobile sources, although indoor sources also contribute to air toxicity. Emissions from stationary sources are classified as major sources or area sources. The threshold for emissions from major sources is 20,000 pounds per year of any single HAP and 50,000 pounds per year of a combination of HAPs. Emissions from area sources may also be monitored in instances when the cumulative effect of emissions below the threshold is potentially dangerous. Mobile sources refer mainly to transportation. Much lower thresholds have been enacted for Persistent, Bioaccumulative, and Toxic (PBT) chemicals since 2000 but this is beyond the time period of the current study (EPA 2007b). Exposure to hazardous air pollutants can increase the risk of contracting cancer, damage the immune and central nervous systems, and cause numerous reproductive and developmental problems (EPA 2007c). While health problems primarily result from exposure in the air, deposits of hazardous air pollutants can accumulate in soil and water and negatively affect plant and animal populations. The sum of all 188 pollutants regulated at the county level is examined here.[16]

Hazardous waste sites, often referred to as Superfund sites, are another source of environmental contamination. These have received some attention in the migration literature and at the county level the effects on net migration have been studied. This paper considers the effects of sites on the National Priorities List (NPL) on inmigration, outmigration, and net migration. These abandoned hazardous waste sites are considered to be of most immediate importance. This is also an interesting complement to the other measures of contamination because the major concern with hazardous waste sites is sediment, soil, and ground water contamination (Rupashinga and Goetz 2004).[17]

The three measures used in this paper, toxic chemical releases, hazardous air pollutants, and hazardous waste sites, are not subject to strict regulatory emissions limits. This is unlike the six criteria air pollutants that are subject to strict ambient concentration limits established by the EPA. Toxic chemical releases and hazardous air pollutant emissions are monitored but there are no standard concentration level benchmarks. The intent of the monitoring programs is to provide reliable information to communities as a basis of action. Hazardous waste site cleanup is considerably more complicated but again there is no strict federal limitation that is applicable. Based on this, these measures are able to provide insight into responses to environmental contamination when strict regulatory limitations are absent. This is not to say that no consequences exist, because communities have used the monitoring information to demand pollution remediation.

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[16] More information and the full list of regulated pollutants can be found at the EPA Toxic Air Pollutants website: http://www.epa.gov/oar/toxicair/newtoxics.html.
[17] For additional information on Superfund sites see: http://www.epa.gov/superfund/about.htm.

3.3.4 Empirical Methodology

The empirical model is estimated using spatial econometric methods that address the need to account for space in county migration observations. LeSage's Spatial Econometric Toolbox for MATLAB was used to perform the estimation (LeSage 1999). Sample data on migration behavior at the county level likely contain an important locational aspect. Empirically this relationship is described as either spatial dependence or spatial heterogeneity. Spatial dependence, or spatial autocorrelation, is present when an observation for one county is dependent in some way on observations taken from proximate counties. The explanatory variables in the empirical model may not be fixed in repeated sampling (LeSage 1999). Two common causes of spatial dependence are measurement error and the importance of spatial interactions. County borders are arbitrary political boundaries and may not be consistent with processes driving migration behavior. If several counties constitute a single labor market area and workers move with regard to labor market areas, not county borders, the accuracy of the county observations is compromised. In addition, space and location are an important component of the relationships being modeled. Changes in migration behavior in a county could be explained to some extent by migration patterns in surrounding counties. A county experiences inmigration (or outmigration) because a neighboring county is attracting (or losing) migrants. Spatial heterogeneity is present when there is spatial variation in the relationships being estimated. A spatial pattern exists in the error term and violates the assumption that all disturbances have the same variance and are not correlated. In a model of county migration, this means that different relationships describe migration flows at different locations (LeSage 1999).

Two commonly employed specifications are considered to deal with the presence of spatial dependence. The spatial autoregressive model (SAR) identifies spatial dependence by including a spatial lag of the dependent variable as an explanatory variable. If spatial dependence is present, failure to control for it through a spatial lag is analogous to omitting a relevant variable and produces biased estimates and inaccurate parameter inferences. The spatial error model (SEM) corrects for spatial heterogeneity in the error term. Failure to correct this spatial pattern in the error term leads to inefficient estimates and biased standard errors. Biased standard errors can lead to incorrect inferences about the statistical significance of parameter estimates. Economic theory suggests use of the SAR model because county migration patterns are likely to have some dependence on patterns in neighboring counties. In addition, omitting a spatial lag when it should be included in the specification is a greater problem than ignoring spatial correlation in the error term (Anselin et al. 1996). Although it is not reported, both the SAR and the SEM specifications were estimated separately. Examination of the log-likelihood statistics and the coefficient estimates for the spatial lag and spatial error terms from these estimations is evidence that it is appropriate to account for spatial dependence through a spatial lag. Based on this, the empirical model is of the following form:

$$MIG = \rho W(MIG) + X\beta + \varepsilon,$$
$$\varepsilon \sim N(0, \sigma^2 I_n)$$

where *MIG* is an nx1vector of the migration variable, *X* is a matrix of explanatory variables, β represents the parameters of the explanatory variables to be estimated, and ε is a random disturbance term. *W* is a first-order row standardized spatial weight matrix and ρ is the coefficient on the spatial lag (LeSage 1999).

3.4 Estimation Results

3.4.1 Variables of Interest

Two sets of estimation results are presented in an effort to accurately portray the relationship between toxic chemical releases and domestic migration at the county level. The estimation results in Table 3.2 and Table 3.3 include total on-site toxic chemical releases.[18] Table 4 presents estimates of on-site toxic chemical releases disaggregated into releases to air, water, underground, and land. Table 3.4 does not present the estimates of other explanatory variables due to space limitations; however they are included in the regression estimation and are unchanged from the results in Tables 3.2 and 3.3. Data are available for 2,202 counties for 1995, the beginning of the migration period. A county may have no data because no facilities in the county meet the threshold to report to TRI or "facilities reporting to TRI in the particular county did not report to TRI for the user-specified selection criteria" (EPA 2008). Generally, the counties not reporting to TRI are rural with small populations and may have no releases to report. The average population of the excluded counties is 12,691 compared with an average population of 111,655 in the included counties. The mean per capita income of the excluded counties is $16,826, the mean housing value is $56,005, and the average employment growth from 1990 to 1995 is 10.17 percent. For the included counties, the mean per capita income is $18,847, the mean housing value is $70,759, and the average employment growth from 1990 to 1995 is 10.84 percent. The excluded counties have a mean inmigration rate of 19.51 percent and a mean outmigration rate of 19.42 percent while the mean inmigration rate among included counties is 18.20 and the mean

[18] In order to consider possible effects of county land area, the alternative measure toxic chemical releases per square mile was estimated. The results were unchanged qualitatively. The same is true for a measure of hazardous air pollutants per square mile.

Table 3.2. SAR Estimation Results with Toxics Release Inventory

Variable	Inmigration nonpoor	Outmigration nonpoor	Net nonpoor
Constant	-2.5547	8.3664	-9.4307
	(14.69)	(9.25)	(9.33)
On-site releases (000s)	-7.88E-05	-1.68E-06	-3.60E-05
	(12.83)	(0.89)	(12.67)
Income (000s)	0.1798	0.1335	-0.0412
	(4.97)	(6.13)	(1.20)
Employment	0.1484	-0.0116	0.1419
	(16.47)	(1.99)	(16.34)
Housing (000s)	0.0252	-0.0150	0.0380
	(5.75)	(4.92)	(8.78)
Density	-0.0019	0.0005	-0.0017
	(7.85)	(7.06)	(6.27)
Density Sq.	3.85E-08	-2.96E-09	4.14E-08
	(6.24)	(9.25)	(8.81)
Crime	-0.0286	0.0076	-0.0332
	(5.11)	(2.00)	(6.20)
January sun	0.0095	0.0082	0.0001
	(3.05)	(3.20)	(0.03)
January temp.	0.0178	-0.0422	0.0415
	(1.72)	(5.40)	(4.06)
July humidity	-0.0174	-0.0367	0.0107
	(2.36)	(6.36)	(1.47)
July temp.	0.0354	0.0153	0.0690
	(2.04)	(1.58)	(4.18)
Coastal	-0.2261	-0.2368	-0.4579
	(9.24)	(9.49)	(6.09)
Health	0.0002	0.0007	-0.0004
	(0.66)	(3.54)	(1.53)
Welfare	-0.0027	-0.0004	-0.0027
	(2.98)	(0.62)	(3.04)
Education	9.20E-05	-2.30E-05	1.28E-04
	(2.07)	(0.76)	(2.97)
Total taxes	2.20E-05	3.77E-04	-4.29E-04
	(0.15)	(3.75)	(3.00)
Primary	-0.0787	-0.0434	-0.0097
	(2.68)	(2.16)	(0.34)
Construction	0.4472	-0.1638	0.5672
	(9.87)	(8.75)	(17.00)
Manufacturing	-0.0818	-0.1097	0.0540
	(7.46)	(14.14)	(5.02)
Transport	-0.0636	-0.0269	0.0109
	(1.45)	(0.95)	(0.26)

Trade	-0.1054	-0.1594	0.0580
	(4.20)	(9.65)	(2.40)
FIRE	-0.0136	-0.2286	0.2024
	(1.17)	(29.47)	(17.64)
Metro	0.9253	-0.1663	0.7798
	(11.31)	(10.74)	(11.09)
Rural	-0.2383	0.6348	-1.0295
	(8.33)	(6.59)	(6.97)
College pop.	0.0604	0.5447	-0.6516
	(1.78)	(30.15)	(19.93)
1990 inmigration		0.2446	
		(25.28)	
rho	0.6620	0.3508	0.4710
	(27.71)	(17.40)	(23.83)
R-squared	0.60	0.66	0.56
Log-likelihood stat.	-4,603	-3,499	-4,418
N	2,202	2,202	2,202

Absolute value of t-statistics in parentheses.

outmigration rate is 19.36 percent. The counties in the sample have higher incomes and housing values on average, as would be expected in more populated counties, but the rates of employment growth and migration are similar for included and excluded counties. Sample selection bias does not seem to be a significant problem. For all of the results presented below, rho (ρ) is positive and statistically significant showing it is important to control for spatial dependence.

Table 3.2 presents results for model specifications with three different dependent variables, outmigration, inmigration, and net migration for individuals above poverty level. The estimates show that an increase in on-site releases of toxic chemicals reduces the rate of nonpoor inmigration and ultimately leads to a net loss of migrants. The coefficient estimate for nonpoor outmigration is not statistically significant. Based on the coefficient estimates, the actual magnitude of the effect on nonpoor migration is limited. An increase of 1,000,000 pounds released on site reduces inmigration by 0.079

percentage points and net migration by 0.036 percentage points. The mean level of on-site releases is 1,035,829 pounds in 1995, although 81 counties have releases of more than 5,000,000 pounds for this year and account for 51 percent of all on-site chemical releases. Large toxic chemical releases tend to be concentrated in relatively few counties. The elasticity of nonpoor inmigration with respect to on-site toxic chemical releases, based on the point estimate and variable means, is -0.004. A one standard deviation increase (3,727,010 pounds) in toxic chemical releases reduces inmigration 0.29 percentage points.

The relationships between toxic chemical releases and nonpoor migration are an illustration of the importance of including migration flow data. The estimates for total on-site releases reveal the expected relationship that toxic chemical releases are unattractive to nonpoor migrants, however the rate of outmigration does not increase as more toxic chemicals are released. Potential migrants could find this environmental contamination undesirable while residents are accustomed to the environmental conditions or place a lower value on environmental quality. Equilibrium migration models predict similar behavior as individuals sort themselves to locations that satisfy their demand for location amenities. These findings are generally consistent with previous work in the area and support the conclusions of Rupashinga and Goetz (2004) with respect to net migration.

Turning to the results describing the migration behavior of the poor, Table 3.3 shows that on-site releases of toxic chemicals are statistically significant for inmigration, outmigration, and net migration. A 1,000,000 pound increase in on-site releases causes a 0.076 percentage point reduction in poor inmigration and a 0.041 percentage point drop

Table 3.3. SAR Estimation Results with Toxics Release Inventory

Variable	Inmigration poor	Outmigration poor	Net poor
Constant	29.6287	38.8866	-6.4177
	(12.37)	(9.65)	(13.16)
On-site releases (000s)	-7.57E-05	-4.10E-05	-2.65E-05
	(3.71)	(6.07)	(2.07)
Income (000s)	0.1435	0.6591	-0.6739
	(1.54)	(14.22)	(6.90)
Employment	0.1091	-0.0182	0.0888
	(5.47)	(1.80)	(4.20)
Housing (000s)	0.0580	0.0351	-0.0023
	(3.87)	(4.22)	(0.17)
Density	-0.0031	-0.0011	-0.0012
	(11.43)	(8.18)	(4.07)
Density Sq.	5.77E-08	6.10E-08	-8.30E-09
	(7.17)	(8.07)	(7.27)
Crime	-0.0629	-0.0688	0.0293
	(4.45)	(9.57)	(1.99)
January sun	0.0173	0.0089	0.0117
	(1.09)	(0.93)	(0.94)
January temp.	-0.1874	-0.2977	0.0766
	(3.61)	(8.00)	(2.00)
July humidity	-0.2080	-0.1351	-0.0125
	(5.73)	(6.15)	(0.44)
July temp.	-0.3656	-0.0632	-0.3646
	(6.55)	(1.81)	(7.07)
Coastal	0.9685	0.6286	1.1580
	(6.10)	(7.38)	(7.67)
Health	0.0006	0.0009	-0.0004
	(0.95)	(2.87)	(0.65)
Welfare	0.0041	-0.0004	0.0042
	(1.64)	(0.33)	(1.67)
Education	-2.43E-04	-3.50E-05	-1.73E-04
	(2.10)	(0.61)	(1.45)
Total taxes	-1.46E-04	5.70E-04	-8.62E-04
	(0.39)	(3.08)	(2.24)
Primary	0.0071	0.0481	-0.0608
	(0.09)	(1.25)	(0.77)
Construction	0.5383	-0.0095	0.4610
	(5.26)	(0.18)	(4.23)
Manufacturing	-0.0166	-0.0270	0.0595
	(0.54)	(1.71)	(1.92)
Transport	-0.0163	0.0941	-0.0546
	(0.16)	(1.84)	(0.50)

Trade	0.0470	-0.0696	0.1463
	(0.82)	(2.47)	(2.38)
FIRE	0.5753	-0.3915	0.9951
	(13.25)	(16.24)	(24.44)
Metro	-0.5937	-0.3181	-1.1965
	(12.73)	(14.29)	(9.35)
Rural	0.0047	-0.2881	0.4827
	(3.98)	(7.61)	(7.16)
College pop.	3.9726	0.0062	3.6718
	(32.61)	(0.15)	(36.71)
1990 inmigration		0.3823	
		(18.14)	
rho	-0.2700	-0.3760	-0.1830
	(11.27)	(12.03)	(10.49)
R-squared	0.65	0.67	0.56
Log-likelihood stat.	-6,316	-4,839	-6,380
N	2,202	2,202	2,202

Absolute value of t-statistics in parentheses.

in outmigration. Net migration falls 0.027 percentage points. The elasticity of poor inmigration with respect to total on-site releases, based on the point estimate and the median inmigration rate, is -0.004. The median is used for poor migration elasticity calculations due to the effects of college populations covered above. The calculation for poor outmigration finds an elasticity of -0.002. The same one standard deviation increase in releases examined above reduces poor inmigration 0.28 percentage points and poor outmigration 0.15 percentage points. An increase in toxic chemicals released is associated with a reduction in the rate of inmigration, outmigration, and net migration for the poor.

The disaggregated measures in Table 3.4 show that the different release media have a statistically signification relationship with nonpoor migration. Releases to air reduce the rate of immigration, outmigration, and net migration. Toxic chemical releases to air are the most prevalent of the four as they make up nearly 64 percent of all chemical

Table 3.4. SAR Estimation Results Disaggregated by Release Method

	Inmigration nonpoor	Outmigration nonpoor	Net nonpoor
Air (000s)	-6.14E-05	-3.28E-05	-3.72E-05
	(7.30)	(2.14)	(3.90)
Water (000s)	-2.82E-04	1.29E-05	-1.58E-04
	(2.28)	(0.17)	(1.35)
Underground (000s)	-2.22E-04	8.77E-05	-2.44E-04
	(7.35)	(2.19)	(7.59)
Land (000s)	-6.94E-05	-3.05E-06	-4.30E-05
	(3.34)	(0.23)	(3.03)

	Inmigration poor	Outmigration poor	Net poor
Air (000s)	-2.01E-04	-1.41E-04	-4.07E-05
	(1.95)	(2.79)	(0.73)
Water (000s)	-1.06E-04	-3.49E-05	-8.01E-05
	(0.37)	(0.25)	(0.26)
Underground (000s)	-1.39E-04	5.22E-05	-2.45E-04
	(0.77)	(0.58)	(1.53)
Land (000s)	4.37E-05	1.17E-05	-2.36E-05
	(0.97)	(2.41)	(0.30)

Absolute value of t-statistics in parentheses.

releases. Water and underground injection each account for nearly 10 percent of releases, and slightly more than 16 percent of chemical releases are to land. Underground injection is concentrated in a small number of counties (69 counties report an underground release in 1995), but releases in these counties are generally very substantial. Chemical releases to surface water and land are more common. Releases through these methods deter nonpoor inmigration and underground and land releases result in a lower rate of net migration. The relationship between poor migration and the disaggregated measures of releases is much more tenuous. None of the four has a statistically significant association with net migration. Air releases decrease the rate of inmigration and outmigration and land releases increase poor outmigration. The disaggregated estimation results are evidence that nonpoor migrants are more sensitive to toxic chemical releases compared with poor migrants. All four release types deter nonpoor inmigration and air, underground, and land releases are associated with a reduced net migration rate. For the poor, only air releases deter inmigration and none of the release types is associated with a reduction in net migration. The coefficient estimates are somewhat small and could suggest a limited economic impact. However, large releases are geographically concentrated and a number of counties experience large releases of toxic chemicals that could substantially impact migration flows.

The results from the TRI data provide evidence that toxic pollution has a role in the migration decision and the data confirm that releases are prevalent, particularly to the air. In an effort to fully examine the relationship between environmental contamination and county migration, HAPs monitored under the Clean Air Act are introduced as an independent variable along with hazardous waste sites on the NPL. HAPs is a pollution measure that has not been studied in the migration literature. Regulation under the Clean Air Act requires a higher threshold level but monitors all emission sources, not specific industries, and provides data for all counties. There are 3,053 observations taken from the contiguous 48 states. Three counties are dropped from the specifications looking at poor migration because these counties contained fewer than 100 total individuals below the poverty line, for a total of 3,050 observations.[19]

Table 3.5 presents the estimation results for specifications including HAPs and hazardous waste sites. For the nonpoor, HAP emissions act as a deterrent to inmigration and outmigration but do not lead to a net loss of migrants. A 1,000,000 pound increase in HAP emissions decreases inmigration by 0.091 percentage points and decreases

[19] The three excluded counties are Hinsdale County, CO; Arthur County, NE; and Hooker County, NE.

Table 3.5. SAR Estimation Results with Hazardous Air Pollutants

Variable	Inmigration nonpoor	Outmigration nonpoor	Net nonpoor
Constant	3.9972	9.9211	-4.3794
	(14.86)	(10.52)	(16.92)
HAP (000s)	-9.12E-05	-6.20E-05	-1.16E-05
	(6.06)	(6.16)	(0.71)
Superfund	-0.4273	-0.1203	-0.2004
	(9.42)	(8.14)	(6.67)
Income (000s)	0.2008	0.1505	-0.0094
	(5.64)	(6.16)	(0.26)
Employment	0.0881	-0.0095	0.0903
	(16.86)	(2.76)	(17.04)
Housing (000s)	0.0257	-0.0141	0.0297
	(6.52)	(5.12)	(7.47)
Density	-0.0014	0.0009	-0.0015
	(11.97)	(11.14)	(13.34)
Density Sq.	5.63E-08	-4.13E-09	3.65E-08
	(4.28)	(7.75)	(7.10)
Crime	-0.0298	0.0191	-0.0424
	(5.66)	(5.48)	(7.96)
January sun	0.0075	0.0108	-0.0027
	(2.56)	(5.26)	(0.92)
January temp.	0.0509	-0.0367	0.0685
	(5.21)	(5.63)	(6.79)
July humidity	-0.0344	-0.0577	0.0122
	(5.16)	(17.16)	(1.85)
July temp.	-0.0081	-0.0118	0.0363
	(0.56)	(1.98)	(2.46)
Coastal	-0.3206	-0.0002	-0.5862
	(4.20)	(1.22)	(8.36)
Health	-0.0004	0.0007	-0.0010
	(1.78)	(4.24)	(3.80)
Welfare	-0.0021	-0.0009	-0.0014
	(3.22)	(1.99)	(2.14)
Education	5.80E-05	2.20E-05	3.80E-05
	(2.01)	(1.17)	(1.31)
Total taxes	-2.30E-05	5.35E-04	-5.96E-04
	(0.19)	(6.57)	(4.78)
Primary	-0.0887	-0.0591	-0.0112
	(4.34)	(4.27)	(0.54)
Construction	0.4268	-0.1538	0.5389
	(12.26)	(6.61)	(15.23)
Manufacturing	-0.0983	-0.1044	0.0360
	(9.96)	(15.30)	(3.57)

Transport	-0.1632	-0.0317	-0.0789
	(4.45)	(1.30)	(2.11)
Trade	-0.1251	-0.1189	0.0129
	(5.85)	(8.43)	(0.59)
FIRE	0.0697	-0.2090	0.2439
	(1.30)	(5.92)	(4.46)
Metro	1.3953	-0.3528	1.2125
	(7.79)	(5.59)	(6.76)
Rural	-0.3813	0.8131	-1.2285
	(9.99)	(8.09)	(9.40)
College pop.	0.0334	0.5100	-0.6549
	(1.10)	(24.33)	(21.14)
1990 inmigration		0.2453	
		(31.16)	
rho	0.6010	0.3280	0.4420
	(39.86)	(10.68)	(24.73)
R-squared	0.59	0.66	0.52
Log-likelihood stat.	-6,486	-5,099	-6,495
N	3,053	3,053	3,053

Absolute value of t-statistics in parentheses.

outmigration 0.062 percentage points. Counties emitted 3,207,162 pounds of HAPs on average in 1999. The elasticity of inmigration with respect to HAP emissions, based on the point estimate and the variable means, is -0.016. A one percent increase in emissions results in a 0.016 percent decrease in county inmigration. The elasticity for outmigration is similar at -0.011. Equivalently, a ten percent increase in average HAP emissions (slightly more than 320,000 pounds) reduces nonpoor inmigration 0.16 percent and nonpoor outmigration 0.11 percent. A one standard deviation increase in emissions (approximately 6,829,828 pounds) leads to a 0.623 percentage point reduction in inmigration, a substantial change in attractiveness to nonpoor migrants. The same one standard deviation increase in emissions reduces outmigration 0.423 percentage points.

Table 3.6 shows that the situation for the poor is similar. HAPs have a negative relationship with inmigration and outmigration of poor individuals. The coefficient for

Table 3.6. **SAR Estimation Results with Hazardous Air Pollutants**

Variable	Inmigration poor	Outmigration poor	Net poor
Constant	35.1035	-3.6781	-4.7175
	(7.44)	(6.74)	(6.02)
HAP (000s)	-1.67E-04	-8.62E-05	-4.15E-05
	(4.46)	(4.73)	(1.07)
Superfund	-0.6303	-0.1913	-0.3465
	(9.71)	(7.36)	(6.89)
Income (000s)	0.2586	0.6124	-0.4423
	(2.80)	(15.65)	(5.23)
Employment	0.0841	0.0127	0.0651
	(7.47)	(2.00)	(5.28)
Housing (000s)	0.0436	0.0068	-0.0132
	(3.66)	(1.40)	(1.14)
Density	-0.0022	-0.0012	-0.0009
	(7.72)	(8.94)	(2.99)
Density Sq.	7.41E-08	5.25E-09	-1.68E-09
	(6.80)	(7.41)	(5.07)
Crime	-0.0525	-0.0446	0.0136
	(4.10)	(7.02)	(1.00)
January sun	0.0315	-0.0049	0.0160
	(2.24)	(1.37)	(1.53)
January temp.	-0.1983	-0.1738	0.0673
	(4.05)	(12.55)	(1.97)
July humidity	-0.1863	-0.0796	0.0214
	(5.83)	(9.40)	(0.90)
July temp.	-0.3557	0.1613	-0.3358
	(7.05)	(8.64)	(8.71)
Coastal	0.9391	0.4743	0.3647
	(7.16)	(8.70)	(6.22)
Health	0.0000	0.0010	-0.0004
	(0.02)	(3.26)	(0.59)
Welfare	0.0008	-0.0010	0.0014
	(0.55)	(1.32)	(0.84)
Education	-4.32E-05	-4.49E-06	-4.60E-05
	(0.62)	(0.10)	(0.66)
Total taxes	1.34E-04	6.50E-04	-7.66E-04
	(0.46)	(4.38)	(2.47)
Primary	-0.0619	0.0240	-0.0846
	(1.17)	(0.97)	(1.54)
Construction	0.4354	-0.0648	0.3940
	(5.50)	(1.56)	(4.69)
Manufacturing	-0.1107	-0.0111	-0.0465
	(4.28)	(0.92)	(1.77)

Transport	-0.1183	0.1121	-0.1745
	(1.45)	(2.51)	(1.97)
Trade	-0.0822	-0.0131	0.0139
	(1.74)	(0.52)	(0.28)
FIRE	0.4350	-0.1967	0.6596
	(3.66)	(13.68)	(19.58)
Metro	-0.2242	-0.3693	-1.0817
	(6.93)	(5.16)	(4.43)
Rural	-0.7168	0.2645	0.0875
	(5.92)	(6.68)	(6.33)
College pop.	3.7200	0.0282	3.4959
	(33.30)	(0.73)	(37.80)
1990 inmigration		0.3400	
		(20.71)	
rho	0.3370	0.4570	0.2230
	(12.61)	(25.67)	(12.17)
R-squared	0.62	0.61	0.50
Log-likelihood stat.	-8,878	-7,003	9,025
N	3,050	3,050	3,050

Absolute value of t-statistics in parentheses.

net migration is not statistically significant. In keeping with the example above, a 1,000,000 pound in HAP emissions reduces poor inmigration 0.167 percentage points and reduces poor outmigration 0.086 percentage points. The coefficient estimate of HAPs for inmigration of the poor is statistically larger than that for the nonpoor at the five percent level of significance.[20] The estimates of the effect of HAPs on outmigration are not statistically different between the poor and nonpoor. The elasticity of poor inmigration with respect to HAP emissions, based on the point estimate, the mean of emissions, and median migration rate, is -0.024. A one percent increase in emissions results in a 0.024 percent decrease in inmigration of the poor. The elasticity of poor outmigration with respect to emissions is -0.012. The same one standard deviation increase in emissions from above reduces poor inmigration 1.14 percentage points and reduces poor

[20] The method used is suggested by Brame et al. (1998) for testing coefficient equality between two samples using maximum likelihood esimation.

outmigration 0.59 percentage points. Air pollution has similar impacts on migration behavior of the nonpoor and the poor. There is no apparent systematic difference in the way that nonpoor and poor migrants respond to toxic chemicals and HAPs. The main result is that counties with more pollution or environmental contamination have reduced rates on inmigration and outmigration but do not lose migrants on net. This pattern is expected if residents sort themselves based in some part on valuation of environmental quality.

Large increases in HAP emissions do have consequential effects on migration behavior of the nonpoor and poor. Statistics on HAP emissions at the county level provide some context about the likelihood of the increases and amounts referenced. In 1999, 122 counties (4 percent of the sample) report greater than 15,000,000 pounds of emissions and the total from these 122 counties represents 33 percent of all HAP emissions. 233 counties (nearly 8 percent of the sample) report more than 10,000,000 pounds of emissions and account for nearly 47 percent of all emissions. Finally, 487 counties (16 percent of the sample) report more than 5,000,000 pounds and are responsible for 65 percent of total HAP emissions. Much like toxic chemical releases, the majority of HAP emissions are concentrated in a small number of high polluting counties. Table 3.7 provides specific emissions and elasticity estimates with respect to nonpoor migration for selected counties in the sample. Counties with lower levels of HAP emissions are not likely to experience large changes in migration behavior as a result. However, the table shows that counties with relatively high emission levels can experience substantial migration impacts. A one percent increase in HAP emissions in counties with the most pollution decreases inmigration and to a lesser extent

Table 3.7. Elasticity With Respect To HAP Emissions, Nonpoor Migration in Selected Counties.

			Elasticity	
Description	County	HAPs (000s)	Inmigration	Outmigration
Least emissions	Loup, NE	40.34	-2.12E-04	-2.33E-04
2nd least	Logan, NE	41.94	-1.73E-04	-1.47E-04
3rd least	Worth, MO	45.26	-2.85E-04	-1.18E-04
10th percentile	Crockett, TN	266.4	-0.001	-0.001
25th percentile	Swain, NC	519.9	-0.003	-0.002
Median	Eagle, CO	1,217.3	-0.003	-0.002
75th percentile	Monroe, PA	3,063.96	-0.010	-0.010
90th percentile	Warrick, IN	7,931.98	-0.033	-0.026
95th percentile	Norfolk, MA	12,974.04	-0.068	-0.042
99th percentile	Person, NC	28,025.24	-0.163	-0.151
3rd highest	Harris, TX	82,865.68	-0.634	-0.329
2nd highest	Cook, IL	97,810.1	-1.268	-0.427
Highest emissions	Los Angeles, CA	200,483.9	-2.694	-0.954

outmigration. These are economically developed counties associated with large metropolitan areas. This is consistent with the interpretation suggested by the estimation results; it takes a sufficiently large level of air contamination to meaningfully effect migration behavior.

The presence of a hazardous waste site reduces inmigration, outmigration, and net migration for the nonpoor. An additional hazardous waste site on the NPL leads to a 0.43 percentage point drop in inmigration, a 0.12 percentage point drop in outmigration, and a reduction in net migration of 0.20 percentage points. The results for poor migrants are very similar. An additional hazardous waste site reduces poor inmigration 0.63 percentage points, poor outmigration 0.19 percentage points, and net migration falls 0.35 percentage points. The reduced rate of both inmigration and outmigration in the presence of a NPL site is most likely evidence of preference sorting. Individuals that place a high value on environmental quality avoid areas with hazardous waste sites. Those with a lower demand for environmental quality are not deterred by the presence of hazardous waste sites. The equilibrium model of migration predicts such behavior as migrants sort themselves based on their demand for location-specific amenities.

3.4.2 Control Variables

The other explanatory variable estimates provide information on the determinants of poor and nonpoor migration. Nonpoor migrants are attracted to counties with a higher per capita income, higher median housing value, and more employment growth. These results are as expected, potential migrants prefer counties with greater economic opportunity. Counties that experience more January sunshine, have warmer January temperatures, and spend more on education are attractive to nonpoor migrants. The estimates for population density reveal a quadratic relationship where increased density is a deterrent but at higher levels becomes attractive to migrants. Crime, July humidity, and increased spending on public welfare are negatively related to nonpoor inmigration. Metropolitan counties experience an increased rate of inmigration while rural counties have a reduced rate of inmigration.

Higher per capita income, crime, more January sunshine, spending on health and hospitals, and higher taxes have a positive relationship with nonpoor outmigration. The estimate on population density is positive and the estimate on density squared in negative, evidence of a nonlinear relationship. Employment growth, higher housing values, warmer temperatures in January and July, higher July humidity, and spending on public welfare are negatively related to the rate of nonpoor outmigration. Metropolitan counties have a lower rate of outmigration while rural counties have increased outmigration among the nonpoor. Controlling for the college age population in a county and previous inmigration is important as both are statistically significant and explain a substantial amount of county outmigration.

The factors that lead to a net gain of nonpoor migrants are employment growth, higher housing values, warmer January and July temperatures, and greater July humidity. Population density, crime, spending on health and hospitals and public welfare, and higher taxes decrease nonpoor net migration. Metropolitan counties have a net gain of nonpoor migrants while coastal and rural counties have a net loss of migrants. The estimate on college age population shows that it is necessary to control for the flow of college students in this type of estimation. County industrial structure is also an important characteristic in explaining migration flows. A higher proportion of employment in the construction industry is the only industrial sector associated with an increase in the inmigration rate for the nonpoor. The primary, manufacturing, transportation, and trade industries all have a negative relationship with nonpoor inmigration. All six measures of industrial structure have a negative and statistically significant relationship with outmigration. Construction and manufacturing are associated with an increase in the net migration rate while trades and finance, insurance, and real estate are associated with a decrease in nonpoor net migration.

Examination of the estimates for poor migration shows that economic opportunity is important and counties with higher per capita income, employment growth, and higher housing values have higher rates of poor inmigration. In addition, coastal counties and those with more January sunshine are attractive to poor migrants. Percent of county population that is college age is a very strong predictor of poor inmigration. A percentage point increase in the percent of the population between 18 and 24 years of age is associated with a 3.72 percentage point increase in poor inmigration. This is a result of the treatment of college students in the migration statistics that consider poverty status. Counties with more crime, higher average temperatures in January and July, and more humidity have a lower rate of poor inmigration. Again, population density has a quadratic relationship with inmigration. Both metropolitan and rural counties are unattractive to poor migrants.

Higher per capita income, employment growth, a higher average temperature in July, spending on health and hospitals, and higher taxes are positively related to poor outmigration. Population density, crime, warmer January temperatures, and increased humidity are negatively related to poor outmigration. Coastal and rural counties have increased rates of poor outmigration while metropolitan counties experience less poor outmigration. Previous inmigration is an important predictor of poor outmigration.

Employment growth and higher January temperatures lead to a net gain of poor migrants. Higher incomes, population density, higher July temperatures, and higher taxes are associated with a net loss of poor migrants. Metropolitan counties have a rather substantial net loss of poor migrants while coastal and rural counties gain poor migrants on net. It is necessary to control for college age population when attempting to explain migration flows of the poor. A one percentage point increase in the percent of county population that is college age is associated with a 3.5 percentage point increase in poor net migration. Again, this should not be considered an accurate causal relationship as it is attributed to the treatment of the college student population in the statistics. As with nonpoor migration flows, it is important to consider industrial structure when attempting to explain poor migration flows. Higher proportions of county employment in construction and finance, insurance, and real estate are associated with an increase in the poor inmigration rate and employment in the manufacturing industry has a negative relationship with poor inmigration. Transportation and finance, insurance, and real estate are associated with a reduction in poor outmigration and the other industries do not have a statistically significant relationship with poor outmigration. Higher proportions of county employment in the construction and finance, insurance, and real estate industries are positively associated with poor net migration while the transportation industry contributes to a reduction in poor net migration.

3.5 Conclusion

This paper investigates a possible role for environmental contamination in the migration decision. Migration research has established that location specific amenities are an important determinant of migration patterns. Previous work generally focuses on climate and local government factors. Recently, authors have examined the effects of pollution and the related health risks, at the state and county level. The current paper is the first to look specifically at toxic chemical releases and other forms of environmental degradation and county migration. In an effort to accurately document all effects, inmigration, outmigration, and net migration are examined. In addition, the results are disaggregated based on poverty status to uncover any possible differences in migration behavior explained by income. Spatial dependence of the county migration observations is controlled for using the spatial autoregressive model (LeSage1999). The findings are that on-site toxic chemical releases affect migration, and results are presented based on disaggregation of releases to air, water, land, and underground. For the nonpoor, toxic chemical releases decrease inmigration and net migration, but do not effect the rate of outmigration. The results for poor migrants show a reduction in inmigration, outmigration, and net migration.

Based on these findings, HAPs and hazardous waste sites are evaluated separately. It is found that HAPs decrease inmigration and outmigration of the nonpoor and poor but are not statistically significant with respect to net migration for either group. Considerable effort is given to evaluate the economic importance of the relationship. The conclusion is that large increases in HAP emissions alter migration patterns substantially. Hazardous waste sites reduce inmigration, outmigration, and net migration rates for the nonpoor and poor. The results presented here support the small amount of previous work and highlight the importance of less studied location amenities. Previous work has shown that migrants respond to environmental amenities and the results presented here lead to the conclusion that migrants are also responsive to environmental contamination. It is interesting that the environmental qualities examined in this paper can be affected by policies at the national, state, and local level.

Chapter 4:

A Role for Air Pollution in Domestic Mobility

4.1 Introduction

The U.S. Environmental Protection Agency (EPA) and Google Earth have recently made it possible to gather air pollutant emission statistics for any facility in the United States in seven major industries with the click of a computer mouse. The program is freely downloadable, and a related application provides daily air quality information and forecasts. The U.S. EPA maintains a number of programs directed at increasing access to air quality information. The Air Quality Index (AQI), which is often referenced in local weather reports, is a color coded tool that provides the public with daily air quality information specific to their community. In the real estate market, home buyers are now able to find air quality information, along with climate averages and neighborhood characteristics, in online property listings in many parts of the country.[21] Reliable and useful information on ambient air quality and pollutant emissions is widely accessible to residents and potential migrants in many forms.

A number of studies within the urban economics literature have concentrated on the role that air quality and other amenities consumed by residents play in the determination of housing values. Related to this, relationships between non-traded amenities and domestic mobility have received considerable attention in the migration literature. An extensive study of air pollution and air quality is a notable exception in the migration literature. This paper presents a straightforward question; does air pollution affect domestic migration behavior? Measures of inmigration, outmigration, and net migration for nonpoor and poor migrants at the county level are utilized. Disaggregation by poverty status allows for investigation of differences in demand for air quality based on income. After controlling for variation in economic opportunity and other location-

[21] Two examples in the Greater Pittsburgh area are Northwood Realty Services (www.northwood.com) and Howard Hanna Real Estate (www.howardhanna.com).

specific characteristics, spatial econometric techniques are introduced to account for spatial dependence in the measures of migration.

The conclusion is that six criteria air pollutants tracked by the EPA do have a statistically and economically significant impact on migration behavior. Increasing criteria air pollutant emissions decreases the rate of inmigration, outmigration, and net migration for the nonpoor. Similarly, for poor migrants the rate of inmigration and outmigration is reduced. This result holds qualitatively when the measure of emissions is restricted to point sources. Of particular importance with respect to migration, is county designation as "nonattainment" for exceeding allowable ambient concentrations for any of the six criteria air pollutants. Nonattainment counties have less nonpoor inmigration and outmigration and ultimately a reduced rate of net migration. Nonattainment counties experience reduced inmigration, outmigration, and net migration among the poor. This result is relevant for a number of counties that may fall into nonattainment due to strengthened ground-level ozone standards (Eilperin 2008). The result is not specific to variable measurement, as it is shown that having more days with unhealthy levels of air pollution has consequences for county migration flows. The findings reveal that migrants are sensitive to differences in air quality and air pollution.

4.2 Literature Review

4.2.1 Models of Migration

An extensive literature exists within regional economics that examines the various determinants of domestic migration. Models of migration behavior can be classified as disequilibrium or equilibrium. Disequilibrium models argue that spatial differences in utility are the driving force behind individual or household migration. Utility differences arise from variations in economic opportunity which may be represented by expected income, unemployment, or an increase in employment opportunities. These models assume that spatial differences persist, that interregional labor markets do not adjust quickly, and therefore households move towards areas of higher expected utility. The prominence of employment factors in the migration decision originates from the view of Sjaastad (1962) that migration is an investment in human capital. Disequilibrium models have been studied by Greenwood and Hunt (1984), Greenwood, Hunt, and McDowell (1986) and Greenwood and Hunt (1989). Disequilibrium type models dominated early work attempting to explain domestic migration (Greenwood 1985).

Equilibrium models argue that spatial variation in economic opportunities is more accurately seen as compensating differentials that correspond to differences in location amenities. Wages are necessarily higher and rents lower in undesirable locations while workers are willing to accept lower wages and pay higher rents to live in areas with desirable amenities. In these models, land and labor markets are considered efficient and migration assures that any spatial variation in utility does not persist. Equilibrium compensating differentials are quickly restored. Persistent migration results from changes in demand for consumption of location-specific amenities or from changes in the supply of amenities at various locations. Demand for amenities could change over the life-cycle or as income levels rise under the assumption that amenities are normal goods. Non-traded location-specific goods take two forms, local government spending and taxation (Tiebout 1956) and a more general amenity bundle that includes factors such as climate and recreation. Human capital investment, public goods provision, and amenities are all addressed in the current model.[22]

The empirical work in equilibrium settings has focused on the importance of amenities and disamenities in the migration decision. Graves (1980) examines the relationship between climate and economic opportunity with data from 49 SMSAs between 1965 and 1970 and concludes that observed differences in income and unemployment are the compensation necessary for spatial utility indifference. Investigating this relationship for whites and non-whites, Graves (1979) finds that whites are generally more concerned with unemployment and climate when deciding to migrate while non-whites are concerned with income differentials and are affected very little by climate considerations. The tendency for amenities to gain importance over the life cycle is addressed by Linneman and Graves (1983). An extensive life-cycle study of white males is undertaken by Clark and Hunter (1992) for the period 1970 to 1980. The authors incorporate a large number of explanatory variables to describe economic opportunity, location amenities, and fiscal factors in each county. Variables representing all three factors prove to be important, with economic opportunity dominating during working years and amenities gaining importance for older migrants. As expected, high income taxes are a deterrent during working years while older migrants move to avoid inheritance and estate taxes. The ability of location-specific amenities to attract potential migrants can aid regional economic development (Knapp and Graves 1989).

Conway and Houtenville (1998, 2001) focus on elderly migration primarily because this group is not constrained by a reliance on employment income. It is hypothesized that location-specific characteristics are of greater importance to the elderly

[22] Hunt (1993) provides an overview of disequilibrium and equilibrium models.

for this reason. Using data from the 1990 Census on state gross migration flows of individuals 65 and older, the authors conclude that this age group is concerned with climate and government fiscal policies. Graves and Knapp (1988) provide a theoretical explanation of elderly mobility.

4.2.2 Studies of Air Pollution

Using the structure of the Clean Air Act Amendments, Chay and Greenstone (2005) find that classification as a nonattainment county for the 1970 to 1980 time period led to a significant reduction in total suspended particulates (TSPs) at the county level and a resulting increase in county housing prices. They report an estimated elasticity that ranges between -0.20 and -0.35. This estimate of marginal willingness to pay is substantially higher than that found in a majority of previous research. The authors attribute this to omitted variables and unobserved location choice of heterogeneous individuals based on air quality preferences. By focusing on the time period that encompasses the establishment of nonattainment standards, the authors argue that their estimates represent a more accurate measure of the capitalization of air pollution in housing values by correcting for these two identification problems. Bayer et al. (2006) develop a model that incorporates moving costs in contrast to the traditional hedonic approach that assumes free mobility. The authors focus on particulate matter concentrations and instrument for local air quality with a measure of air pollution attributable to distant sources. They estimate the elasticity of total willingness to pay with respect to air pollution is between -0.34 and -0.43. This is considerably larger than estimates from a conventional model and corresponds to a marginal willingness to pay between \$149 and \$185. The conclusion, in support of Chay and Greenstone (2005), is that housing values do not reflect the complete economic value of air quality improvements. Previous research on the effects of environmental degradation on housing values is reviewed and analyzed by Smith and Huang (1995) and Simons and Saginor (2006)

With regard to effects on industrial activity, Henderson (1996) concludes air quality regulation, specifically ambient ozone levels, at the county level is of importance for the 1977-1987 time period. Polluting industries show a tendency to move from nonattainment counties with more strict regulation to attainment counties. Designation as a nonattainment county results in a three to eight percent reduction in ground-level ozone. Similarly, Greenstone (2002) finds that nonattainment counties experience a reduction in industrial activity. The study examines the first 15 years of county classification (1972-1987) and reports a significant decrease in jobs, capital stock, and output for violating counties. It is necessary to examine the benefits of cleaner air to arrive at a decision on merits of these policies, but these papers show that regulation does affect industrial activity. Berman and Bui (1998) investigate the effects of air pollution regulation on oil refineries in the Los Angeles Air Basin from 1979 to 1992. Despite the relatively strict regulation in the Los Angeles area, oil refineries experienced an increase in productivity over the period 1987 to 1992 while refineries in the other regions experienced a decline in productivity. In a related paper (Berman and Bui 2001), the authors conclude that local air pollution regulation has not substantially decreased employment in the Los Angeles region. In a more general study, Goetz et al. (1996) find better environmental conditions are positively related to state personal income growth from 1982 to 1991.

More stringent environmental regulations do not have a statistically significant affect on growth. Jaffe et al. (1995) provide an overview of this literature.

The economic effects of air pollution on individuals have been studied in a variety of ways. Using the Health Interview Survey for 1976, Hausman et al. (1983) find a statistically significant relationship between total suspended particulates and work days lost. More recently, Hansen and Selte (2000) report a statistically significant relationship between the level of particulate matter and sick-leaves in Oslo, Norway. Results are not as clear for sulfur dioxide and nitrogen oxides. Chay and Greenstone (2003) use county nonattainment designation as an instrumental variable and show that the sharp drop in infant mortality from 1971 to 1972 is significantly related to nonattainment status the previous year (the first year the EPA determined attainment status) and the associated decline in TSPs. The authors estimate a 0.5 percent fall in the infant mortality rate for a one percent drop in TSPs. In support of this, Currie and Niedell (2005) find that reductions in carbon monoxide and particulate matter concentrations are responsible for 1,000 fewer infant deaths in California during the 1990s. Currie et al. (2007) report that a higher number of days when the level of carbon monoxide exceeds or approaches air quality standards results in increased absences at elementary and middle schools in 39 Texas school districts. This has important implications for human capital formation. The reviewed literature presents a strong case that air pollution impacts economic decision making.

4.3 Data and Methodology

4.3.1 Data

The migration model in this paper parallels that used by Clark and Hunter (1992) and is standard in the migration literature. Migrants attempt to maximize utility when choosing between alternative locations. The decision is based on the goods provided at each location, the cost of these goods, and the economic opportunities available. Migrants can consume private goods and location-specific goods. Migration is necessary if an individual or household wishes to consumer more (or less) of a specific location characteristic. The focus of this paper is on location-specific disamenities. The empirical model takes the following form:

$$\mathbf{MIG_i = f(ECONOPP,\ AMENITIES,\ TAXEXP)}$$

Migration is dependent upon economic opportunities (**ECONOPP**), the combination of amenities and disamenities (**AMENITIES**), and government taxation and expenditure on public goods (**TAXEXP**). The empirical model investigates the distinction between poor migrants and nonpoor migrants. Level of income could result in a systematic difference in migration behavior. Policies and characteristics that are attractive to poor migrants may be deterrents to the nonpoor, and vice versa. Lower income individuals are less able to incur the costs of relocation and could find a larger quantity of affordable housing in locations that would be undesirable to the nonpoor. Assuming air quality is a normal good, individuals with higher income should display an increased affinity for areas with cleaner air. Nord (1998) provides a comprehensive look at differences in migration behavior between counties based on income level. The author finds that the poor are as mobile as the nonpoor but differences in response to county characteristics lead to spatial concentrations of poor individuals.

Equilibrium migration models explain relocation as a response to changes in demand for location-specific amenities. An increase in income could be the catalyst for a demand change and a stronger preference for clean air and environment. Another possibility is a change in the supply of amenities, in this case clean air, at different locations. In this regard, air pollution differs from climate and some other characteristics because the supply of clean air at any location can change noticeably over a relatively short time period. It is just as likely that the dispersion of information on air quality provides residents and potential migrants with knowledge of a previously unknown or ignored environmental characteristic. For the current study, designation as a nonattainment county almost surely represents the largest information impact. Even if the supply of clean air does not change drastically (or at all), innovative information could effectively change what residents and migrants see as the supply of clean air at a location. Similarly, additional information on potential health consequences associated with air pollution could affect location desirability. More and better information could be manifested in location decisions.

Specific dependent and explanatory variables employed to measure migration behavior and county characteristics are described in the table below. Explanatory variables are measures at the beginning of the migration period or as near as possible. The dependent variable is measured in three separate ways as inmigration, outmigration, and net migration at the county level. Rogers (1990) formalizes the limitations and bias of uniregional net migration measures and cautions against the interpretation of results from models attempting to explain net migration. Measures of inmigration and outmigration are preferable and more accurately depict the migration process while not

Table 4.1. Data Description and Sources

Variable	Description	Source
Dependent Variables		
Nonpoor inmigration	Nonpoor inmigration as a percent of 1995 population above poverty line, 1995-2000	U.S. Census Bureau
Nonpoor outmigration	Nonpoor outmigration as a percent of 1995 population above poverty line, 1995-2000	U.S. Census Bureau
Nonpoor net migration	Nonpoor net migration as a percent of 1995 population above poverty line, 1995-2000	U.S. Census Bureau
Poor inmigration	Poor inmigration as a percent of 1995 population below poverty line, 1995-2000	U.S. Census Bureau
Poor outmigration	Poor outmigration as a percent of 1995 population below poverty line, 1995-2000	U.S. Census Bureau
Poor net migration	Poor net migration as a percent of 1995 population below poverty line, 1995-2000	U.S. Census Bureau
Explanatory Variables		
Total Emissions	Thousands of tons of six criteria air pollutants emitted from point and non-point sources, 1996	U.S. EPA
Nonattainment	Exceeds allowable ambient concentrations for any criteria air pollutant 1994, 1995=1, else=0	U.S. EPA
AQI	Number of days in 1995 the Air Quality Index measured above 100	U.S. EPA
Income	Per capita personal income, 1995	BEA REIS
Employment	Percentage growth in total employment, 1990-1995	BEA REIS
Median value	Median value of owner-occupied housing, mean of 1990 and 2000 value	U.S. Census Bureau
Density	County population per square mile	Computed
Density Squared	County population density squared	Computed
Crime	Number of violent crimes and property crimes per 1000 population, 1995	USA Counties
January temp.	Average January temperature	NORSIS
July temp.	Average July temperature	NORSIS
January sun	Percent of possible January sunshine	NORSIS
July humidity	Average July humidity	NORSIS
Coastal	Coastal county=1, else=0	NORSIS
Health	County health and hospitals expenditures per capita, 1997	USA Counties
Welfare	County public welfare expenditures per capita, 1997	USA Counties
Education	County education expenditures per student,	USA Counties

	1997	
Taxes	Total county taxes per capita, 1997	USA Counties
Primary	Proportion of total private non-farm employment in agricultural services, fishing, forestry, and mining, 1995	BEA REIS
Manufacturing	Proportion of total private non-farm employment in manufacturing, 1995	BEA REIS
Construction	Proportion of total private non-farm employment in construction, 1995	BEA REIS
Trade	Proportion of total private non-farm employment in wholesale and retail trade, 1995	BEA REIS
Transport	Proportion of total private non-farm employment in transportation, 1995	BEA REIS
FIRE	Proportion of total private non-farm employment in financial services, insurance, and real estate, 1995	BEA REIS
Metro	Metropolitan county=1, else=0	USDA ERS
Rural	Nonmetropolitan county not adjacent to a metropolitan county=1, else=0	USDA ERS
College pop.	Percent of total county population between 18 and 24 years of age, 1995	U.S. Census Bureau
1990 inmigration	Inmigration from 1985 to 1990 as a percent of county population in 1985	U.S. Census Bureau
BEA REIS, Bureau of Economic Analysis Regional Economic Information System; NORSIS, National Outdoor Recreation Supply Information System; USDA ERS, Unites States Department of Agriculture Economic Research Service; U.S. EPA TRI, Environmental Protection Agency Toxics Release Inventory		

being confounded by population stock levels. Studies that rely on a single measure of migration are limited in their depiction of the true migration process. Additionally, each of these measures is disaggregated by poverty status.

This disaggregation by poverty status reveals a peculiar pattern of poor migration for multiple counties. Counties containing a college or university experience very elevated rates of poor inmigration. In the migration statistics obtained from the U.S. Census Bureau, many college students are considered poor inmigrants and therefore the influx of poor migrants is excessively large compared with the poor population in the county. This leads to very large inmigration rates, exceeding 100 percent, in some counties. The higher rate of poor inmigration is most noticeable for counties with large universities that do not also contain a large metropolitan area. However, the effect can be large in sparsely populated counties with a small number of poor residents that contain a smaller college or university branch campus. Monongalia County, West Virginia provides a telling example of the effects of a larger university. In 1999 (when poverty status is determined for Census migration purposes), Monongalia County contained 8,253 residents classified as poor and 61,042 residents classified as nonpoor. The campus of West Virginia University is located within the county and had an enrollment of approximately 22,000 students for the 2000 fall semester. The treatment of many of these students as poor inmigrants results in a poor inmigration rate of 108 percent in 2000. Inmigration is used to calculate net migration and this leads to a poor net migration rate of 89 percent for 2000. A number of other counties containing college and university campuses exhibit a similar pattern. There is an important but less obvious effect on outmigration of the nonpoor from these same counties because poverty status is determined in 1999. Students who have graduated from college or completed graduate school, gained employment, and migrated between 1995 and 1999 are classified as nonpoor and could report their residence five years ago as the university or college town. The result is an inflated nonpoor outmigration rate. Percent of county population between ages 18 and 24 in 1995 is included in each model specification to account for the effects of college populations in the county migration statistics.

Income, median housing value, and employment growth are included to control for economic opportunities in each county. Including measures of income and housing value also ensures that any capitalization of amenities into wages or rents is captured in the model. The percent of total employment in six industry sectors is included to control for the county industrial structure. The climate variables include average January and July temperature, percent of possible sunshine in January, and average July humidity. Population density, population density squared, and the crime rate are additional measures of location amenities. Dummy variables are used for metropolitan counties, rural counties that are not adjacent to metropolitan counties, and coastal counties. Local government spending is taken into account by including expenditures on education, welfare, and health and hospitals. Taxation is measured as total county taxes per capita.

Funding for the study of air pollution and its cleanup was first established by the Clean Air Act of 1963 and with the passage of the Clean Air Act of 1970 the focus on air pollution increased substantially. The EPA was created the same year, and its primary task was to carry out the laws established by the expanded Clean Air Act. The Clear Air Act of 1990 further revised and expanded the previous legislation and provided the EPA expanded authority (EPA 2007a). Currently, the EPA places particular importance on six criteria, or common, air pollutants. These include: particulate matter smaller than 2.5 micrometers and smaller than 10 micrometers in diameter, ground-level ozone (O_3), carbon monoxide (CO), sulfur dioxide (SO_2, nitrogen oxides (NO_x), and lead (Pb_3). These are known as criteria air pollutants because each has set permissible levels mandated by the EPA[23]. Primary standards are based on human health while secondary standards are concerned with environmental and property damage. Exposure to these common air pollutants can irritate the respiratory system and increase the probability of infection, damage the lungs, create breathing problems, and aggravate asthma symptoms.

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[23] An overview of the six criteria air pollutants is available from the EPA at: http://www.epa.gov/air/urbanair/. Information on criteria air pollutant emissions trends is available at: http://www.epa.gov/ttn/chief/trends/.

Those with existing conditions, the elderly, and the young are at the highest risk. In addition, air pollution can damage crops, harm wildlife and the environment, contaminate water sources, and damage structures (EPA 2007a).

EPA collects data on ambient concentrations of these pollutants at the county level for measurements of proximate air quality. While this likely provides the most accurate assessment of local air quality, information on emissions is also of interest. This paper utilizes EPA data on the direct emissions of criteria air pollutants and substances that promote the formation of criteria air pollutants, while ambient concentrations above allowable limits are considered below. Specific data exist for emissions of carbon monoxide (CO), sulfur dioxide (SO_2), and particulate matter smaller than 2.5 micrometers and smaller than 10 micrometers as these are the criteria pollutants emitted directly into the atmosphere. The majority of carbon monoxide emissions originate from motor vehicles, while non-road vehicles and engines are smaller sources. Fuel combustion for electric utilities is responsible for over 60 percent of sulfur dioxide emissions. Industrial facilities that utilize raw materials and natural resources are the second largest emitter of sulfur dioxide. Particulate matter can be emitted directly and can also result from the reaction of other materials. Matter that is between 2.5 micrometers and 10 micrometers in diameter is labeled by the EPA as "inhalable course particles". "Fine particles" are matter less than 2.5 micrometers in diameter (EPA 2008a).

In addition, data on the emissions of volatile organic compounds (VOC), nitrogen oxides (NO_x), and ammonia (NH_3) are available. Each of these is considered to be a precursor or promoter of criteria air pollutants. Nitrogen oxides are a criteria air pollutant and are emitted directly but they also react with other materials to form different air pollutants. Nitrogen oxides are a byproduct of fuel combustion with motor vehicles as the primary source of emissions. Electric utilities and commercial and industrial facilities are substantial secondary sources. Volatile organic compounds and nitrogen oxides are the main components in the formation of ground-level ozone. Sunlight facilitates the reaction of these two materials in the atmosphere. Similarly, sulfur dioxide and nitrogen oxides, along with water vapor, are the principal components in the formation of particulate matter and acid precipitation. Ammonia also reacts with nitric and sulfuric acids to create fine particulate matter. Lead is a criteria air pollutant, but EPA tracks it separately as a hazardous air pollutant, as discussed below (EPA 2008a).

Geographic areas that are not able to meet the National Ambient Air Quality Standards (NAAQS) can be classified as "nonattainment" areas.[24] Nonattainment classification can refer to an entire county or part of a county. For the present analysis, counties that were designated in whole, or in part, in 1994 or 1995 are treated as nonattainment counties. Annual designation occurs on July 1 of each year. Therefore, a county designated nonattainment in 1994 could achieve attainment status prior to July 1, 1995 and this would not be reflected in the designations for the first half of 1995 (EPA 2008b). The result is 469 counties classified as nonattainment in the sample. The 1-hour ozone standard was revoked on June 15, 2005 and is now applicable only to 8-hour ozone nonattainment counties associated with Early Action Compact Areas. This does not

[24] National Ambient Air Quality Standards: carbon monoxide, 9 ppm (8-hour average), 35 ppm (1-hour average); lead, 1.5 micrograms per cubic meter (quarterly); nitrogen dioxide, 0.053 ppm (annual, mean); particulate matter 2.5, 150 micrograms per cubic meter (24-hour average); particulate matter 10, 15 micrograms per cubic meter (annual, mean), 35 micrograms per cubic meter (24-hour average); ozone, 0.75 ppm (8-hour average, updated March 2008), 0.12 ppm (1-hour average); sulfur dioxides, 0.03 ppm (annual, mean), 0.14 ppm (24-hour average). (Source: http://www.epa.gov/air/criteria.html)

affect the current sample because the 1-hour ozone standard was in effect for the duration of the time period being studied. Nonattainment designation could be of particular importance because it is likely to be reported, or known, when a county is classified as nonattainment. This provides a signal to residents, businesses, and potential migrants that air pollution is a concern. This does not require information or understanding about emissions levels and is a less costly source of information. The announcement could have a substantial impact on location choices above and beyond the actual level of air pollution.

The final measure examined is the AQI. This is a measure of daily air quality and is based on measurements of ground-level ozone, particulate matter, carbon monoxide, sulfur dioxide, and nitrogen oxides. The index ranges from 0 to 500 and is divided as follows: 0-50, good; 51-100, moderate; 101-150, unhealthy for sensitive groups; 151-200, unhealthy; 201-300, very unhealthy; 301-500, hazardous (EPA 2003). The U.S. EPA records the number of days in the year a county receives a score above 100 and this is the measure used here. Again, this is a relatively accessible source of daily air quality information that is unique to air pollution.

4.3.2 Empirical Methodology

The empirical model is estimated using spatial econometric methods that address the need to account for space in county migration observations. LeSage's Spatial Econometric Toolbox for MATLAB was used to perform the estimation (LeSage 1999). Sample data on migration behavior at the county level likely contains an important locational aspect. Empirically this relationship is described as either spatial dependence or spatial heterogeneity. Spatial dependence, or spatial autocorrelation, is present when an observation for one county is dependent in some way on observations taken from proximate counties. The explanatory variables in the empirical model may not be fixed in repeated sampling (LeSage 1999). Two common causes of spatial dependence are measurement error and the importance of spatial interactions. County borders are arbitrary political boundaries and may not be consistent with processes driving migration behavior. If several counties constitute a single labor market area and workers move with regard to labor market areas, not county borders, the accuracy of the county observations is compromised. In addition, space and location are an important component of the relationships being modeled. Changes in migration behavior in a county could be explained to some extent by migration patterns in surrounding counties. A county experiences inmigration (or outmigration) because a neighboring county is attracting (or losing) migrants. Spatial heterogeneity is present when there is spatial variation in the relationships being estimated. A spatial pattern exists in the error term and violates the assumption that all disturbances have the same variance and are not correlated. In a model of county migration, this means that different relationships describe migration flows at different locations (LeSage 1999).

Two commonly employed specifications are considered to deal with the presence of spatial dependence. The spatial autoregressive model (SAR) identifies spatial dependence by including a spatial lag of the dependent variable as an explanatory variable. If spatial dependence is present, failure to control for it through a spatial lag is analogous to omitting a relevant variable and produces biased estimates and inaccurate parameter inferences. The spatial error model (SEM) corrects for spatial heterogeneity in the error term. Failure to correct this spatial pattern in the error term leads to inefficient estimates and biased standard errors. Biased standard errors can lead to incorrect inferences about the statistical significance of parameter estimates. Economic theory suggests use of the SAR model because county migration patterns are likely to have some dependence on patterns in neighboring counties. In addition, omitting a spatial lag when it should be included in the specification is a greater problem than ignoring spatial correlation in the error term (Anselin et. al. 1996). Although it is not reported, both the SAR and the SEM specifications were estimated separately. Examination of the log-likelihood statistics and the coefficient estimates for the spatial lag and spatial error terms from these estimations is further evidence that it is appropriate to account for spatial dependence through a spatial lag. Based on this, the empirical model is of the following form:

$$MIG = \rho W(MIG) + X\beta + \varepsilon,$$
$$\varepsilon \sim N(0, \sigma^2 I_n)$$

where *MIG* is an nx1vector of the migration variable, X is a matrix of explanatory variables, β represents the parameters of the explanatory variables to be estimated, and ε is a random disturbance term. W is a first-order row standardized spatial weight matrix and ρ is the coefficient on the spatial lag (LeSage 1999).

4.4 Empirical Results

The results reported in this section are based on total emissions of all six criteria air pollutants. In the Appendix, complete results are shown for the individual air pollutants. Table 4.2 presents the results of the SAR estimation with inmigration, outmigration, and net migration of the nonpoor as dependent variables. Emissions data are available for

Table 4.2. SAR Estimation Results with Emissions and Nonattainment

Variable	Nonpoor inmigration	Nonpoor outmigration	Nonpoor net
Constant	4.9470	10.1580	-3.9436
	(9.53)	(7.93)	(8.25)
Total emission (000s)	-0.0074	-0.0042	-0.0018
	(9.60)	(7.87)	(2.25)
Nonattainment	-1.4623	-0.6011	-0.7203
	(14.34)	(12.98)	(10.79)
Income (000s)	0.2193	0.1582	-0.0027
	(6.17)	(6.34)	(0.07)
Employment	0.0883	-0.0102	0.0901
	(16.99)	(2.95)	(17.01)
Housing (000s)	0.0252	-0.0134	0.0299
	(6.50)	(4.77)	(7.55)
Density	-0.0010	0.0010	-0.0014
	(8.93)	(13.27)	(12.18)
Density Sq.	4.93E-08	-7.33E-09	2.25E-08
	(6.03)	(5.79)	(7.84)
Crime	-0.0286	0.0194	-0.0421
	(5.50)	(5.50)	(7.95)
January sun	0.0072	0.0109	-0.0032
	(2.48)	(5.05)	(1.08)
January temp.	0.0610	-0.0345	0.0725
	(6.33)	(4.97)	(7.23)
July humidity	-0.0394	-0.0596	0.0100
	(5.97)	(14.16)	(1.52)
July temp.	-0.0239	-0.0159	0.0299
	(1.67)	(1.98)	(2.03)
Coastal	-0.6208	-0.1099	-0.6833
	(9.13)	(7.75)	(10.67)
Health	-0.0005	0.0007	-0.0010
	(1.94)	(4.04)	(3.88)
Welfare	-0.0020	-0.0008	-0.0013
	(3.06)	(1.84)	(2.04)
Education	4.90E-05	1.90E-05	3.40E-05
	(1.73)	(1.05)	(1.15)
Total taxes	8.00E-06	5.39E-04	-5.79E-04
	(0.07)	(6.56)	(4.66)
Primary	-0.0889	-0.0595	-0.0109
	(4.38)	(4.24)	(0.52)
Construction	0.4357	-0.1543	0.5395
	(12.57)	(6.60)	(15.23)
Manufacturing	-0.1010	-0.1056	0.0347
	(10.32)	(15.22)	(3.45)

Transport	-0.1453	-0.0274	-0.0696
	(3.99)	(1.12)	(1.86)
Trade	-0.1188	-0.1167	0.0151
	(5.59)	(8.27)	(0.69)
FIRE	0.0731	-0.2083	0.2425
	(1.37)	(5.88)	(4.43)
Metro	1.7676	-0.1963	1.3782
	(6.29)	(5.32)	(6.47)
Rural	-0.4240	0.7853	-1.2326
	(4.78)	(4.38)	(4.11)
College pop.	0.0292	0.5118	-0.6559
	(0.97)	(24.34)	(21.21)
1990 inmigration		0.2446	
		(19.08)	
rho	0.5970	0.3270	0.4489
	(19.96)	(13.34)	(25.12)
R-squared	0.59	0.66	0.52
Log-likelihood stat.	-6,468	-5,086	-6,494
N	3,053	3,053	3,053

Absolute value of t-statistics in parentheses.

3,053 counties in 1996.[25] The parameter estimates show that a 10,000 ton increase in total emissions reduces the nonpoor inmigration rate 0.074 percentage points. The estimates also show that the same 10,000 ton increase in emissions leads to a 0.042 percentage point reduction in nonpoor outmigration. Counties with higher levels of emissions are unattractive to potential inmigrants, however residents of the same counties are also less likely to depart. The mean county emission of criteria air pollutants is 70,695 tons in 1996 and the median is 32,174 tons. Based on the point estimate and the mean of each variable, the elasticity of nonpoor inmigration with respect to total emissions is -0.028. A one percent increase in criteria emissions leads to a 0.028 percent reduction in inmigration. The elasticity of outmigration with respect to total emissions is slightly less at -0.017. Looking at another measure of the relationship between air

[25] In order to consider possible effects of county land area, the alternative measure criteria air pollutant emissions per square mile was estimated. The estimation results were qualitatively equivalent.

pollution and migration shows that relatively large increases in emissions can have a substantial impact on migration patterns. A one standard deviation increase in total criteria emissions (approximately 133,000 tons) results in a 0.99 percentage point reduction in nonpoor inmigration and a 0.56 percentage point drop in outmigration. The effects on net migration of individuals above the poverty line are less substantial, but higher emissions result in a loss of migrants on net. A 10,000 ton increase in emissions leads to a drop in the net migration rate of 0.018 percentage points and a one standard deviation increase is associated with a drop of 0.24 percentage points.

Table 4.2 also reveals that classification as a nonattainment county has significant implications for migratory behavior. Exceeding air quality standards for at least one of the six criteria air pollutants reduces nonpoor inmigration by 1.46 percentage points, a 7.9 percent drop. Outmigration declines by 0.60 percentage points as a result of nonattainment status, 3.4 percent, and the reduction in nonpoor net migration is 0.72 percentage points.

The results for nonpoor migration flows disclose two important issues. First, examination of only the net migration rate fails to accurately describe the effects of air pollution and nonattainment designation. Counties with more emissions and those designated nonattainment have a reduced rate of inmigration but also experience less outmigration. Mobility in these counties is less than that in counties with fewer emissions and counties that are in attainment. Second, classification as nonattainment appears to represent an important announcement effect. Nonattainment status is a clear signal to residents or potential migrants that air pollution is a concern within the county and is at or near potentially dangerous levels. The estimation results confirm the expectation that this regulatory signal plays an important role in the migration decision.

The results for the estimation of poor migration are presented in Table 4.3. For the three specifications explaining inmigration, outmigration, and net migration there are 3,050 observations. Three counties are excluded because they contained fewer than 100 total individuals below the poverty line for this time period.[26] Criteria air pollutant emissions cause a statistically significant reduction in poor inmigration and outmigration. A 10,000 ton increase in total emissions is associated with a 0.114 percentage point reduction in poor inmigration. The decrease in outmigration is 0.060 percentage points. An increase of one standard deviation (slightly more than 133,000 tons), reduces poor inmigration 1.52 percentage points and poor outmigration 0.80 percentage points. The mean rate of poor inmigration is 25.64 percent compared with an average inmigration rate of 18.55 for the nonpoor. The mean outmigration rate for the poor is 25.11 percent and 17.58 for the nonpoor. The poor are more mobile than the nonpoor, however the treatment of college students in the migration statistics inflates the inmigration rate of poor individuals in multiple counties. Because of this, elasticities are calculated using the median rates of inmigration (22.19) and outmigration (24.03) for the poor. Based on the point estimate, mean criteria emissions, and median migration rate, the elasticity of poor inmigration with respect to total emissions is -0.036. The elasticity of poor outmigration with respect to total emissions is -0.018. As with the nonpoor, it seems that relatively small increases in criteria emissions have a negligible impact on county migration behavior while large increases in emissions have substantial effects. There is not a statistically significant relationship with poor net migration. The result that counties with

[26] The three excluded counties are Hinsdale County, CO, Arthur County, NE, and Hooker County, NE.

Table 4.3. SAR Estimation Results with Emissions and Nonattainment

Variable	Poor inmigration	Poor outmigration	Poor net
Constant	33.6748	-3.0831	-5.0736
	(8.12)	(6.65)	(7.75)
Total emission (000s)	-0.0114	-0.0060	-0.0022
	(6.14)	(6.30)	(1.14)
Nonattainment	-3.3243	-1.2465	-2.2950
	(6.75)	(7.77)	(7.43)
Income (000s)	0.2916	0.6320	-0.4270
	(3.14)	(15.95)	(5.25)
Employment	0.0846	0.0124	0.0648
	(7.49)	(1.97)	(5.26)
Housing (000s)	0.0440	0.0078	-0.0104
	(3.72)	(1.62)	(0.93)
Density	-0.0017	-0.0009	-0.0007
	(5.87)	(6.77)	(2.38)
Density Sq.	6.11E-08	9.41E-09	-1.38E-09
	(8.00)	(7.30)	(5.10)
Crime	-0.0500	-0.0446	0.0123
	(3.92)	(7.06)	(0.90)
January sun	0.0315	-0.0053	0.0136
	(2.30)	(1.48)	(1.25)
January temp.	-0.1925	-0.1675	0.0710
	(4.17)	(12.19)	(2.04)
July humidity	-0.1980	-0.0841	0.0173
	(6.41)	(9.99)	(0.68)
July temp.	-0.3493	0.1512	-0.3286
	(7.39)	(8.12)	(12.05)
Coastal	0.6209	0.3125	0.0942
	(6.40)	(6.59)	(7.73)
Health	0.0000	0.0009	-0.0004
	(0.06)	(3.08)	(0.65)
Welfare	0.0010	-0.0009	0.0015
	(0.62)	(1.22)	(0.88)
Education	-4.40E-05	-8.00E-06	-5.20E-05
	(0.69)	(0.23)	(0.74)
Total taxes	2.13E-04	6.81E-04	-7.20E-04
	(0.73)	(4.60)	(2.32)
Primary	-0.0676	0.0230	-0.0817
	(1.28)	(0.93)	(1.50)
Construction	0.4443	-0.0632	0.3927
	(5.60)	(1.52)	(4.78)
Manufacturing	-0.1120	-0.0138	-0.0463
	(4.34)	(1.16)	(1.79)

Transport	-0.1060	0.1238	-0.1626
	(1.30)	(2.78)	(1.87)
Trade	-0.0725	-0.0088	0.0173
	(1.53)	(0.35)	(0.36)
FIRE	0.4696	-0.1914	0.6585
	(3.93)	(13.43)	(22.23)
Metro	0.2083	-0.0208	-0.7316
	(6.42)	(5.54)	(5.79)
Rural	-0.7298	0.2247	0.0096
	(6.27)	(5.92)	(6.32)
College pop.	3.7300	0.0294	3.4870
	(36.73)	(0.76)	(31.66)
1990 inmigration		0.3344	
		(20.40)	
rho	0.3170	0.4560	0.2380
	(13.95)	(25.74)	(7.63)
R-squared	0.61	0.61	0.51
Log-likelihood stat.	-8,868	-6,992	-9,022
N	3,050	3,050	3,050

Absolute value of t-statistics in parentheses.

more pollutant emissions do not lose poor migrants on net is interesting, but should not be overstated prior to examination of the nonattainment effects.

Nonattainment status has serious consequences for the mobility of the poor. If a county is designated nonattainment by the EPA, the inmigration rate of the poor is estimated to fall 3.32 percentage points, or 12.9 percent. The estimated effect of criteria emissions on poor inmigration is statistically larger than the effect on nonpoor inmigration at the five percent level of significance.[27] The rate of outmigration drops 1.25 percentage points, 5.0 percent, and net migration falls 2.30 percentage points. As with inmigration, the effect is statistically larger for poor outmigration compared with nonpoor outmigration at the ten percent level of significance. The substantial impacts on poor mobility are somewhat unexpected if air quality is assumed to be a normal good.

[27] The method used is suggested by Brame et al. (1998) for testing coefficient equality between two samples using maximum likelihood estimation.

This could be a product of industrial relocation to attainment counties. To some extent there could be lingering effects of the treatment of college students as poor immigrants, although this is controlled for in the estimation. However, the estimates reveal that county designation as nonattainment is an important determinant of poor migration flows. Poor migrants are particularly affected by air quality regulations. The county becomes less attractive to potential inmigrants and outmigration is also reduced, but to a lesser degree. This reduction in the outmigration rate could be preference sorting or it could signify a general reduction in mobility in counties with large amounts of air pollution. The parameter estimate on poor net migration shows that nonattainment counties lose more migrants than they gain, but again net migration alone provides a limited view of the actual migratory process in these counties.

The structure of the emissions data makes it possible to investigate criteria air pollutant emissions exclusively from point sources. These are stationary sources such as industrial factories and power plants that measure emissions individually. This measure of point emissions can also be seen as a proxy for the existence of power plants and large factories that themselves may make proximate locations less attractive. Although the full effect of emissions from point sources is not reflected in local air quality, there is reason to believe that potential migrants could be averse to locating near a point source. Non-point sources include modes of transportation (automobiles, aircraft, and boats), small stationary sources like houses and small offices, and diffuse sources including fires and agriculture. The composition of total emissions differs considerably compared with the composition of point emissions. Carbon monoxide accounts for slightly more than 58 percent of total emissions. The breakdown of point emissions is sulfur dioxide 48 percent, nitrogen oxides 27 percent, carbon monoxide 15 percent, volatile organic compounds 6 percent, particulate matter 3 percent, and ammonia 0.6 percent. Sulfur dioxide and nitrogen oxides are the primary components of emissions from power plants burning fossil fuels.

The full estimation results are presented in Table A2 and Table A3 in the Appendix. The estimation results for this restricted variable of interest show that point emissions have very similar effects on migration compared with overall emissions containing both point and non-point sources. An increase of 10,000 tons of point criteria emissions results in a 0.139 percentage point decrease in nonpoor inmigration and a 0.063 percentage point reduction in nonpoor outmigration. Both of these coefficient estimates are significant at the one percent level. The net migration rate falls 0.052 percentage points and the estimate is significant at the five percent level. Because point emissions are a subset of total emissions and therefore less prevalent (they account for nearly 16 percent of total emissions), the elasticities of nonpoor inmigration and outmigration with respect to point emissions are small. The mean county emission of criteria air pollutants from point sources is 11,128 tons for 1996 and the median is 791 tons. The elasticity of inmigration and outmigration evaluated at the means of the variables is -0.008 and -0.004, respectively. The same 10,000 ton increase in point emissions causes a 0.017 percentage point decrease in poor inmigration and a 0.008 percentage point decrease in poor outmigration. These are both significant at the one percent level, but the coefficient estimate on poor net migration is not statistically significant. The estimates are comparable to those for total emissions although the economic magnitudes are somewhat reduced. Preference sorting could be particularly strong with respect to point emissions because of the concentration of large amounts of emissions in relatively few counties. This is addressed below. According to the estimates, the nonpoor have a stronger response to increases in point emissions and this is just as likely a response to the industrial facilities associated with large point emissions.

The final air pollution measure examined is the number of days that the AQI measured above 100 in the county for the year. A measurement greater than 100 means that the air may be unhealthy for sensitive groups on that day. The full results from this estimation are presented with those for point emissions in Table A2 and Table A3 in the Appendix. An additional day of the AQI measuring above 100 is associated with a 0.088 reduction in nonpoor inmigration, 0.056 reduction in nonpoor outmigration, and a 0.038 decrease in net migration. All three estimates are significant at the one percent level. Once again, the effects on poor migration are substantial. One more day with an AQI measure above 100 leads to a 0.141 percentage point decrease in poor inmigration and a 0.096 percentage point decrease in poor outmigration. The relationship between AQI and poor net migration is not statistically significant. Riverside, California had 110 days with an AQI reading above 100, the most of any county. 32 counties had at least 20 days with a reading above 100 and the mean number of days with an AQI measure above 100 for 1995 is 1.2. The results are further evidence that air pollution does have a significant relationship with county migration flows.

Table 4.4 provides information on the actual level of emissions at the county level in 1996. When looking at total emissions, counties with large populations have the highest emission levels. This is to be expected because the majority of common air pollutants originate from non-point sources, most notably automobiles and homes. Table

Table 4.4. County and Total Emissions Statistics

Criteria Air Pollutant Emissions	Number of Counties	% of Counties	% of Total Emissions	Population in Counties	% of National Population
Over 25,000 tons	1843	60.4	92.6	241,625,297	94.1
Over 50,000 tons	1039	34.0	78.4	217,122,511	84.6
Over 75,000 tons	712	23.3	69.0	197,942,878	77.1
Over 100,000 tons	522	17.1	61.4	181,790,710	70.8
Over 150,000 tons	346	11.3	51.5	161,184,178	62.8
Over 200,000 tons	241	7.9	43.2	143,853,278	56.0
Over 300,000 tons	114	3.7	29.1	105,974,838	41.3
Over 500,000 tons	42	1.4	16.5	68,808,940	26.8

Table 4.5. County and Emissions Statistics for Point Emissions

Criteria Air Pollutant Point Emissions	Number of Counties	% of Total	% of Point Emissions	Population in Counties	% of National Population
Over 5,000 tons	782	25.6	94.2	168,464,211	65.6
Over 7,500 tons	655	21.5	91.9	152,219,869	59.3
Over 10,000 tons	567	18.6	89.6	138,290,024	53.9
Over 15,000 tons	437	14.3	85.0	111,025,224	43.3
Over 25,000 tons	324	10.6	78.4	86,652,850	33.8
Over 50,000 tons	194	6.4	65.1	55,237,728	21.5
Over 100,000 tons	81	2.7	41.7	24,404,001	9.5
Over 150,000 tons	40	1.3	27.0	15,105,464	5.9

4.5 provides a similar breakdown for point emissions. A relatively small number of counties have very high levels of point emissions and account for a large percent of all point emissions; however the population in these same counties is considerably smaller than the population in the counties with high levels of total emissions. Table 4.6 presents actual emissions data for a selection of counties in the sample. The top five counties in total emissions are not surprising and are associated with the following metropolitan areas: Los Angeles, Chicago, Houston, Detroit, and Phoenix. Of the 100 counties with the highest total emissions, 93 are classified as metropolitan counties. The story for point emissions is quite different as the top five counties in point emissions are not associated

Table 4.6. Emissions Statistics for Selected Counties

Description	County	Point Emissions in tons	County	Total Emissions in tons
1	Jefferson, OH	754,312	Los Angeles, CA	3,303,300
2	Washington, OH	373,913	Cook, IL	2,357,504
3	Gallia, OH	363,224	Harris, TX	1,914,677
4	Muhlenberg, KY	360,347	Wayne, MI	1,275,404
5	St. Mary, LA	357,188	Maricopa, AZ	1,248,502
99th percentile	Coshocton, OH	164,129	Palm Beach, FL	589,942
95th percentile	Grant, KS	62,048	Arapahoe, CO	259,762
90th percentile	Platte, MO	28,107	Lexington, SC	164,388
75th percentile	Tate, MS	5,368	Warren, NJ	69,802
Median	Washita, OK	791	Sweet Grass, MT	32,174
25th percentile	Middlesex, VA	53	Humphreys, MS	17,377
10th percentile	537 Counties	0	Perry, TN	10,565

with very large metropolitan areas. Jefferson County, OH contains the Weirton-Steubenville MSA, Washington County, OH contains the Parkersburg-Marietta-Vienna

MSA, and the other three counties are not classified as metropolitan. Of the 100 counties with the highest point emissions, only 54 are classified as metropolitan counties. A substantial number of counties report no point emissions in 1996.

The estimates of the other explanatory variables are consistent with previous literature. As expected, nonpoor migrants are attracted to counties with greater economic opportunity and favorable climate conditions. Crime, population density, and higher taxes are factors that deter nonpoor migrants. Metropolitan counties are attractive to nonpoor migrants while rural counties and coastal counties lose these migrants on net. Economic opportunity is associated with poor inmigration but the results are not as clear for the net migration measure. Only the percent of January sunshine is attractive to poor inmigrants, but counties with warmer January temperatures see a gain on net. As with the nonpoor, higher taxes encourage outmigration of the poor result in a net loss of migrants. Metropolitan counties have a negative relationship with poor net migration while rural and coastal counties have a positive relationship. The coefficient estimates on college age population make it clear that it is important to address the treatment of college students in this data. This is particularly true for poor inmigration and net migration, although it also has a substantial impact on the estimates of nonpoor outmigration and net migration. County industrial structure proves to be an important set of explanatory variables in all specifications. The measures of industrial structure have a stronger statistical relationship with nonpoor migration flows. The positive and significant spatial lag coefficient (ρ) in all specifications is confirmation that addressing spatial dependence is necessary.

4.5 Conclusion

The main finding of this paper is that air pollution has an important relationship with migration patterns at the county level. It is the first paper to extensively examine the role that air quality and air pollution play in mobility decisions. Measures of inmigration, outmigration, and net migration at the county level are disaggregated by poverty status. In the empirical model, a number of variables are included to control for economic opportunities, location-specific amenities, and government taxation and expenditure. The variables of interest are total air pollutant emissions and county designation as nonattainment for exceeding allowable ambient concentrations of an air pollutant. In addition, point air pollutant emissions and the number of days in the year with unhealthy levels of air pollution are examined.

The SAR estimates presented here show that emissions of the six criteria air pollutants monitored by the EPA and designation as a nonattainment county have significant statistical and economic impacts with regard to mobility. Higher emissions decrease inmigration, outmigration, and net migration for the nonpoor. Status as a nonattainment county also reduces inmigration, outmigration, and net migration. Results for poor migration are similar, increased emission levels lead to less inmigration and less outmigration while nonattainment designation reduces inmigration, outmigration, and net migration. There is evidence that nonattainment designation has a larger impact on migration flows of the poor. These results hold for the alternative measures point emissions and number of days with an AQI score above 100. Statistics are also presented on the number of counties emitting various levels of criteria air pollutants. Examination of the statistics reveals that the counties with the highest total emissions are generally metropolitan while the counties with the highest point emissions are much less likely to be metropolitan.

The estimation results are of particular interest in the context of the findings of Bayer et al. (2006) that mobility costs affect the estimation of willingness to pay for clear air. In addition, the EPA recently reduced the allowable ambient concentration of ground-level ozone and understanding possible effects of an increase in the number of counties falling into nonattainment designation on migration is imperative. Air pollution is a deterrent to inmigration but it also results in less outmigration and an overall reduction in mobility. As larger amounts of information on air quality become available and the cost of retrieving the information falls, it is increasingly important to understand the role of air pollution in the migration decision.

Chapter 5:

Conclusion

5.1 Concluding Remarks

This dissertation has examined relationships between domestic migration and public policies at the state and county level. Chapter 2 examines if outmigration is associated with a decrease in financial support for public higher education. Chapters 3 and 4 take a different perspective by attempting to determine if migrants are responsive to environmental contamination and air quality, respectively. The results increase the understanding of individuals' responses to environmental degradation, an issue that has risen in prominence and has important implications for the ability of areas to attract migrants and encourage growth.

Chapter 2 provided insight into one of the possible locational consequences of outmigration by focusing on state and local appropriations to public institutions of higher education. First a theoretical model was derived based on the interaction of a university governing board and a state legislature. Values for the optimal enrollment, tuition, and state appropriation were derived. Appropriations were shown to be a function of the propensity of outmigration. An empirical test was then carried out to determine if mobility significantly affects appropriations to public higher education. Previous studies have found a statistically significant negative relationship between outmigration and state and local appropriations to public higher education. Using a pooled cross-section for the 1989-90 and 1999-00 school years and controlling for other factors that determine spending, a comparable result is found. However, after gross outmigration flows were disaggregated by age into six profiles based on the life-cycle model of migration a clearer picture emerges. Outmigration of the "leaving college" group (age 20 to 29) is not associated with the largest effects on appropriations. The outmigration of the "young families and the labor market" (age 30-44), "families and the labor market" (age 45-64), and "retirement" (age 65-74) groups each have a significant negative relationship with appropriations. The coefficient estimates for the last two groups are the largest but the estimated elasticities show that movement of the 30 to 44 and 45 to 64 age groups have substantial impacts. This result supports a more direct tax revenue link to the observed reduction in appropriations, rather than a response by legislators to the propensity of recent graduates to migrate out of state. It is also clear that outmigration at different stages of the life-cycle has considerably different effects on public higher education financing. In addition, the paper concludes that broad-based state merit scholarship programs have led to higher appropriations per student. Such programs provide a very strong incentive for students to attend higher education in state and necessitate increased spending to balance demand. This result is of particular interest as expansion of these relatively new programs continues and evaluation progresses.

Chapter 3 investigated a possible role for environmental contamination in the migration decision. Migration research has established that location specific amenities are an important determinant of migration patterns. Previous work generally focuses on climate and local government factors. Recently, authors have examined the effects of pollution and the related health risks, at the state and county level. The current paper is the first to look specifically at toxic chemical releases and other forms of environmental degradation and county migration. In an effort to accurately document all effects, inmigration, outmigration, and net migration are examined. In addition, the results are disaggregated based on poverty status to uncover any possible differences in migration behavior explained by income. Spatial dependence of the county migration observations is controlled for using the spatial autoregressive model (LeSage1999). The findings are that on-site toxic chemical releases affect migration, and results are presented based on disaggregation of releases to air, water, land, and underground. For the nonpoor, toxic chemical releases decrease inmigration and net migration, but do not effect the rate of outmigration. The results for poor migrants show a reduction in inmigration, outmigration, and net migration.

Based on these findings, HAPs and hazardous waste sites are evaluated separately. It is found that HAPs decrease inmigration and outmigration of the nonpoor and poor but are not statistically significant with respect to net migration for either group. Considerable effort is given to evaluate the economic importance of the relationship. The conclusion is that large increases in HAP emissions alter migration patterns substantially. Hazardous waste sites reduce inmigration, outmigration, and net migration rates for the nonpoor and poor. The results presented here support the small amount of previous work and highlight the importance of less studied location amenities. Previous work has shown that migrants respond to environmental amenities and the results presented here lead to the conclusion that migrants are also responsive to environmental contamination. Furthermore, state and local governments have some control over the environmental qualities examined in this paper.

The main finding of Chapter 4 is that air pollution has an important relationship with migration patterns at the county level. Recent work has shown that estimates of the marginal willingness to pay for cleaner air derived from traditional hedonic models of housing values are underestimated due to mobility costs (Chay and Greenstone 2005, Bayer et al. 2006). This paper is related in that it is an effort to determine if migrants have a response to air pollution and air quality. Studies of housing values point to a need for examination of the relationship between migration behavior and air quality.

Air quality is an amenity that has not received rigorous examination in the literature. The SAR estimates presented here show that emissions of the six criteria air pollutants monitored by the EPA and designation as a nonattainment county have significant statistical and economic impacts with regard to mobility. Higher emissions decrease inmigration, outmigration, and net migration for the nonpoor. Status as a nonattainment county also reduces inmigration, outmigration, and net migration. Results for poor migration are similar, increased emission levels lead to less inmigration and less outmigration while nonattainment designation reduces inmigration, outmigration, and net migration. These results hold for the alternative measures point emissions and number of days with an AQI score above 100. The EPA recently reduced the allowable ambient concentration of ground-level ozone and understanding possible effects of an increase in the number of counties falling into nonattainment designation on migration is imperative (Eilperin 2008). Air pollution is a deterrent to inmigration but it also results in less outmigration and a general reduction in mobility. This is evidence that individuals engage in preference sorting with respect to air quality as has been shown with other climate characteristics. As larger amounts of information on air quality become available and the cost of retrieving the information falls it is increasingly important to understand the role of air pollution in the migration decision.

5.2 Future Extensions

Possible extensions of the work on the relationship between migration and state support of higher education are to look at differences between 2-year and 4-year institutions and to disaggregate a sample of universities and colleges based on enrollment. It is likely that major state universities with large enrollments are affected differently by migration than other institutions in the state higher education system. This could be particularly important during times of overall reduced support of higher education. I would also like to utilize migration data disaggregated by income level to further explore the relationship uncovered in Chapter 2. In a more general sense, research on the relationship between migration and higher education is timely. As discussed in Chapter 2, a number of states have implemented broad-based merit scholarship programs. The goal of these programs is to retain graduates and reduce the incidence of recent graduates relocating to other states for employment. Currently, a detailed study is difficult because most of these programs have started since 2000 and adequate data do not exist for a sufficient number of states to test the effects of these programs on migration decisions of graduates. However, when data become available it will be important to conduct research on the ability of merit scholarship programs to retain graduates because this is a clear test of the economic justifications of these programs.

Chapters 3 and 4 also suggest some important extensions. These are the first two papers to fully examine a possible relationship between mobility and environmental degradation. These papers use data from the mid-1990s and since this time the quality of pollution data has increased noticeably. As more recent migration data become available it will be possible to examine more aspects of these relationships. With current migration data it will be of interest to disaggregate by age to capture life-cycle effects and increased sensitivity of children and the elderly to air pollution. The elderly could be informative because their migration is not heavily contingent on economic opportunity and therefore they may be more sensitive to environmental degradation. It would also be interesting to restrict the analysis to metropolitan areas to check the robustness of the results. A majority of pollution and emissions originate in metropolitan areas but there is likely to be substantial variation between urban areas.

In a larger sense, the results of the final two chapters suggest that it is appropriate to examine other location disamenities that have yet to receive attention in the literature. It would be interesting to determine if brownfields, redeveloped hazardous waste sites, have any relationship with population movements. If NPL sites are avoided as shown in this dissertation, are brownfields treated any differently by migrants? Another example that I plan to pursue in the near future is the effect of nuclear power plants on migration flows. This has yet to be examined, but migrants may have an aversion to locating near an operating nuclear power plant. A study like this is necessary because the nuclear industry is experiencing a resurgence of late. The number of proposals for new nuclear power plants is increasing and leases on existing plants have been extended. Nuclear power is gaining a more prominent position in the national energy picture and it will be important for decision makers to understand how a power plant could affect the demographics of their population.

Finally, more time needs to be given to an examination of the treatment of college students in the migration statistics. As noted in the final two chapters, the migration statistics can be affected greatly by the movement of college students. In the estimations in this dissertation, it was critical to control for the college age population in models of poor inmigration and net migration and nonpoor outmigration and net migration. The migration literature has not fully dealt with this issue and it may have gone unnoticed in previous work. It is important to gain an understanding of exactly how the treatment of college students affects migration data and estimation results. A similar problem exists with treatment of prison inmates in population statistics. Prisoners are generally counted as residents of the county where they are being held not as residents of the city or country from which they came. The impacts on population tabulations can be sizeable in rural counties that contain large prisons. Population and migration data are used for many metropolitan classifications and these numbers could be inaccurate if the college student population is not properly addressed.

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Appendix

Appendix A

This model is based on Fethke (2006) and some of derived results are unchanged from that work.

University problem:

$$G(P,s) = (P - c + s)(a - bP) + \frac{(a - bP)^2}{2b}$$

$$\frac{\partial G}{\partial P} : a - 2bP + cb - sb - a + bp = 0$$

$$P^* = c - s$$
$$Q^* = a - b(c - s)$$

State legislature problem:

$$L^*(s) = \max_s \alpha(\varphi) M(\gamma) \log Q^*(s) - sQ^*$$

$$\frac{\partial L(s)}{\partial s} : \frac{\alpha M b}{(a - bc + bs)} - a + bc - 2bs = 0$$

$$a^2 - 2abc + 3abs - 3b^2cs + b^2c^2 + 2b^2s^2 - \alpha Mb = 0$$

$$2b^2s^2 + 3Q_c bs + a^2 - 2abc + b^2c^2 - \alpha Mb = 0 \quad \text{where} \quad Q_c \equiv a - bc$$

The quadratic formula is used to solve for s*.

$$s^* = \frac{-3Q_c b \pm \sqrt{9Q_c^2 b^2 - 8b^2(a^2 - 2abc + b^2c^2 - \alpha Mb)}}{4b^2}$$
$$s^* = \frac{Q_c}{4b}\left(\sqrt{\frac{1 + 8\alpha Mb}{Q_c^2}} - 3\right)$$

Comparative static results:

$$\frac{\partial s^*}{\partial a}=\frac{1-3\sqrt{\frac{1+8\alpha Mb}{Q_c^2}}}{4b\sqrt{\frac{1+8\alpha Mb}{Q_c^2}}}<0$$

$$\frac{\partial s^*}{\partial c}=\frac{-\left(1-3\sqrt{\frac{1+8\alpha Mb}{Q_c^2}}\right)}{4\sqrt{\frac{1+8\alpha Mb}{Q_c^2}}}>0$$

$$\frac{\partial s^*}{\partial M}=\frac{\alpha}{Q_c\sqrt{\frac{1+8\alpha Mb}{Q_c^2}}}>0$$

$$\frac{\partial s^*}{\partial \alpha}\frac{\partial \alpha}{\partial \varphi}=\left(\frac{\partial \alpha}{\partial \varphi}\right)\frac{M}{Q_c\sqrt{\frac{1+8\alpha Mb}{Q_c^2}}}<0$$

$$\frac{\partial s^*}{\partial M}\frac{\partial M}{\partial \gamma}=\left(\frac{\partial M}{\partial \gamma}\right)\frac{\alpha}{Q_c\sqrt{\frac{1+8\alpha Mb}{Q_c^2}}}<0$$

Appendix B

The amount of emissions for the six criteria air pollutants shown below shows considerable variation for 1996. The composition of total emissions is as follows: carbon monoxide 58 percent, nitrogen oxides 11 percent, volatile organic compounds 9 percent, sulfur dioxide 8 percent, particulate matter 11 percent, and ammonia 2 percent.

Table B.4.1. SEM Estimation Results with Six Criteria Air Pollutants (000s pounds)

Variable	Inmigration nonpoor	Outmigration nonpoor	Net nonpoor
Carbon monoxide	-1.2E-05	-8.4E-06	-3.4E-06
	(9.49)	(9.64)	(2.81)
Nitrogen oxides	-5.9E-05	-4.5E-05	-1.5E-05
	(9.62)	(9.96)	(2.38)
Volatile organic compounds	-9.1E-05	-5.8E-05	-3.0E-05
	(10.57)	(10.11)	(3.63)
Sulfur dioxide	-2.0E-05	-1.5E-05	-6.3E-06
	(4.44)	(4.53)	(1.35)
Particulate matter	-1.1E-04	-9.1E-05	-1.2E-05
	(9.89)	(10.49)	(0.83)
Ammonia	-4.1E-04	-3.1E-04	-1.3E-04
	(7.10)	(7.33)	(2.16)

Variable	Inmigration poor	Outmigration poor	Net poor
Carbon monoxide	-1.6E-05	-1.3E-05	-3.6E-06
	(5.83)	(8.94)	(1.27)
Nitrogen oxides	-9.4E-05	-6.5E-05	-3.0E-05
	(6.84)	(8.29)	(2.05)
Volatile organic compounds	-1.2E-04	-9.4E-05	-2.7E-05
	(6.59)	(9.37)	(1.42)
Sulfur dioxide	-3.4E-05	-2.1E-05	-9.8E-06
	(3.29)	(3.72)	(0.90)
Particulate matter	-1.8E-04	-1.3E-04	-8.9E-05
	(7.69)	(9.14)	(2.74)
Ammonia	-5.0E-04	-2.6E-04	-2.7E-04
	(3.93)	(3.60)	(4.25)

Absolute value of t-statistics in parentheses.

Table B.4.2. SAR Estimation Results with Point Sources and AQI

Variable	Nonpoor inmigration	Nonpoor outmigration	Nonpoor net
Constant	2.1743	9.3660	-4.5020
	(7.59)	(7.40)	(9.91)
Point emission (000s)	-0.0139	-0.0063	-0.0052
	(5.23)	(3.29)	(2.02)
AQI	-0.0877	-0.0557	-0.0379
	(5.28)	(4.68)	(2.21)
Income (000s)	0.1894	0.1411	-0.0112
	(5.46)	(5.72)	(0.31)
Employment	0.0880	-0.0095	0.0902
	(16.59)	(2.73)	(17.07)
Housing (000s)	0.0212	-0.0145	0.0283
	(5.55)	(5.13)	(7.19)
Density	-0.0017	0.0007	-0.0016
	(5.77)	(5.60)	(4.13)
Density Sq.	4.51E-08	-4.26E-09	5.99E-08
	(7.14)	(7.36)	(8.72)
Crime	-0.0297	0.0175	-0.0417
	(5.78)	(4.98)	(7.99)
January sun	0.0071	0.0115	-0.0027
	(2.55)	(5.24)	(0.92)
January temp.	0.0422	-0.0424	0.0682
	(4.54)	(5.86)	(6.90)
July humidity	-0.0267	-0.0561	0.0131
	(4.10)	(10.71)	(2.01)
July temp.	0.0113	0.0003	0.0383
	(0.81)	(0.03)	(2.63)
Coastal	-0.6189	-0.1416	-0.6948
	(6.75)	(6.29)	(7.49)
Health	-0.0003	0.0007	-0.0009
	(1.36)	(4.40)	(3.68)
Welfare	-0.0020	-0.0008	-0.0013
	(3.18)	(1.86)	(2.03)
Education	5.30E-05	2.10E-05	3.40E-05
	(1.87)	(1.09)	(1.16)
Total taxes	-2.10E-05	5.35E-04	-5.95E-04
	(0.18)	(6.45)	(4.81)
Primary	-0.0766	-0.0527	-0.0078
	(3.84)	(3.74)	(0.38)
Construction	0.4492	-0.1455	0.5461
	(12.67)	(6.20)	(15.48)
Manufacturing	-0.0969	-0.1046	0.0351

	(10.11)	(15.04)	(3.51)
Transport	-0.1489	-0.0279	-0.0695
	(4.07)	(1.13)	(1.85)
Trade	-0.1146	-0.1148	0.0147
	(5.42)	(8.07)	(0.68)
FIRE	0.0327	-0.2295	0.2308
	(0.62)	(6.44)	(4.25)
Metro	1.3234	-0.4024	1.2324
	(7.96)	(5.94)	(7.77)
Rural	-0.4111	0.7783	-1.2443
	(5.85)	(5.74)	(4.63)
College pop.	0.0221	0.5006	-0.6556
	(0.74)	(23.27)	(21.26)
1990 inmigration		0.2530	
		(27.30)	
rho	0.6269	0.3110	0.4530
	(27.61)	(17.12)	(25.44)
R-squared	0.59	0.66	0.52
Log-likelihood stat.	-6,498	-5,104	-6,495
N	3,053	3,053	3,053

Absolute value of t-statistics in parentheses.

Table B.4.3. SAR Estimation Results with Point Sources and AQI

Variable	Poor inmigration	Poor outmigration	Poor net
Constant	33.5188	3.9345	-5.4093
	(8.33)	(5.07)	(8.19)
Point emission (000s)	-0.0173	-0.0077	-0.0063
	(2.99)	(2.35)	(0.99)
AQI	-0.1413	-0.0960	-0.0607
	(3.02)	(4.05)	(1.27)
Income (000s)	0.2144	0.6278	-0.4532
	(2.32)	(14.77)	(5.74)
Employment	0.0874	0.0092	0.0662
	(7.77)	(1.40)	(5.37)
Housing (000s)	0.0427	0.0114	-0.0142
	(3.57)	(2.00)	(1.29)
Density	-0.0028	-0.0013	-0.0011
	(9.91)	(9.00)	(3.65)
Density Sq.	4.41E-08	5.43E-09	-1.23E-09
	(5.71)	(5.60)	(6.92)
Crime	-0.0568	-0.0503	0.0125
	(4.47)	(7.33)	(0.93)

January sun	0.0320	0.0009	0.0155
	(2.25)	(0.19)	(1.41)
January temp.	-0.2139	-0.2450	0.0661
	(4.32)	(14.59)	(1.92)
July humidity	-0.1817	-0.1135	0.0242
	(5.62)	(10.23)	(0.95)
July temp.	-0.3222	0.1677	-0.3236
	(6.31)	(8.27)	(12.10)
Coastal	0.2146	0.5768	0.0212
	(7.63)	(6.21)	(7.10)
Health	0.0001	0.0010	-0.0003
	(0.19)	(3.20)	(0.50)
Welfare	0.0009	-0.0007	0.0014
	(0.58)	(0.80)	(0.86)
Education	-4.50E-05	4.00E-06	-5.20E-05
	(0.70)	(0.11)	(0.73)
Total taxes	1.21E-04	7.28E-04	-7.69E-04
	(0.42)	(4.57)	(2.48)
Primary	-0.0404	0.0354	-0.0750
	(0.76)	(1.29)	(1.39)
Construction	0.4699	-0.0325	0.4080
	(5.92)	(0.74)	(5.04)
Manufacturing	-0.1084	-0.0053	-0.0465
	(4.18)	(0.39)	(1.81)
Transport	-0.1146	0.1229	-0.1682
	(1.40)	(2.65)	(1.94)
Trade	-0.0682	-0.0141	0.0157
	(1.44)	(0.54)	(0.32)
FIRE	0.3858	-0.2537	0.6398
	(3.25)	(14.23)	(21.48)
Metro	-0.4514	-0.4961	-1.1470
	(6.01)	(5.42)	(4.85)
Rural	-0.7968	0.0801	0.0175
	(6.37)	(5.96)	(6.93)
College pop.	3.7071	-0.0430	3.4882
	(32.91)	(1.08)	(32.74)
1990 inmigration		0.4144	
		(22.83)	
rho	0.3460	0.2130	0.2390
	(12.77)	(11.07)	(7.09)
R-squared	0.61	0.59	0.51
Log-likelihood stat.	8,887	7,001	9,026
N	3,050	3,050	3,050

Absolute value of t-statistics in parentheses.

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