The Value of Climate Amenities: Evidence from U.S. Migration Decisions

Paramita Sinha[1] and Maureen L. Cropper[2]

December 31, 2009

Abstract

There is a large literature that attempts to value climate amenities in the US and elsewhere using the fact that climate amenities are capitalized into wages and property values. Many of these estimates, which were produced in the 1970s and 1980s, assume that people are perfectly mobile and are based on estimates of national hedonic wage and property value functions. These functions will yield biased estimates of consumers' willingness-to-pay for climate amenities if consumers are not in locational equilibrium, as may occur due to information or other moving costs.

We value climate amenities by estimating a discrete model of residential location choice for households who changed metropolitan statistical areas (MSAs) between 1995 and 2000. We assume that the utility that a household derives from living in an MSA depends on climate amenities along with earnings potential, housing costs and location-specific amenities. To avoid assuming a national labor market we estimate separate hedonic wage functions for each MSA to predict earnings opportunities in each city. Households choose the MSA where they derive maximum utility. The model is estimated using a two step procedure (Bayer, Keohane and Timmins, 2006). In the first stage, location-specific constants are estimated together with other parameters of the utility function. In the second stage, location-specific intercepts are regressed on location-specific amenities and housing costs to estimate the average utility attached to these amenities.

We find winter temperature and summer precipitation to be amenities, but summer temperature to have no statistically significant effect on migration decisions. Models estimated using "stayers" as well as movers suggest that the former are not in equilibrium; and hence that their location decisions cannot be used to estimate the value they attach to climate amenities.

[1] RTI International
[2] University of Maryland, College Park and Resources for the Future

Section 1: Introduction

Concerns about climate change have renewed interest in the value US citizens place on climate as an amenity. This interest comes from two directions. One is the desire to value changes in temperature and precipitation in order to estimate the welfare effects of various climate impacts and, hence, of climate change mitigation policies. What are the welfare effects of cooler winters and wetter summers in the Southern US and warmer winters in the North, as are predicted to occur under a Business-as-Usual scenario? The second is the desire to predict movements in population that may occur in response to changes in climate. To what extent would winters have to grow warmer and drier in the Northeast and Midwest to stem the tide of migration from these regions to the South and West? More generally, what would be the impact of various climate scenarios on migration patterns in the US?

This paper attempts to inform both questions by modeling the migration decisions of US households between 1995 and 2000, taking into account the role of climate in these decisions. We model the decision of migrants as a choice among 297 MSAs based on potential earnings, housing costs, moving costs, climate amenities and other location-specific amenities. Households are assumed to choose the location from which they derive maximum utility. Under standard assumptions, the probability that the household chooses a location is given by the conditional logit model.

The model is estimated in two stages, following Bayer, Keohane and Timmins (2006). In the first stage, MSA-specific constants are estimated together with other utility function parameters to explain the location choices of migrants. In the second stage, the MSA-specific constants, which may be interpreted as Quality-of-Life indices, are regressed on amenities that vary by MSA to estimate the average utility attached to these amenities. This procedure allows us to identify the parameters of consumers' utility functions and in particular, the preference parameters for climate variables.

There are few recent estimates of the value of climate amenities in the US. Most estimates in the literature are based on hedonic wage and property value functions, following the approach of Rosen (1974) and Roback (1982). These studies, including Cragg and Kahn (1999), Gyourko and Tracy (1991), Blomquist et al. (1988) and Smith (1983), assume that households and firms can migrate costlessly from one location to another and that, as a result, national labor and housing markets are in equilibrium. In reality, this may not be the case: for consumers, impediments to migration include transportation costs, search costs (for jobs and housing), and personal and family considerations. Firms may face barriers to entry into a region. If, as a result, national housing and labor markets are not in equilibrium, the partial derivatives of national hedonic wage and property value functions will not measure marginal willingness to pay for amenities.

Cragg and Kahn (1997) overcome some of these difficulties by valuing climate amenities using a discrete model of location choice. They model the location choices of US households who moved between 1985 and 1990, who are more likely to be in locational equilibrium than all households in the population. When households choose the state in which to live, their earnings opportunities are described by state-specific hedonic wage equations. Cragg and Kahn thus avoid the assumption of a national labor market.

Our paper builds on and extends the work of Cragg and Kahn. Like Cragg and Kahn, we focus on migrant households. It is reasonable to assume that these households are in locational equilibrium and also reasonable to treat conditions in the housing and labor markets in each MSA as exogenous to migrants. We extend Cragg and Kahn by explicitly include moving costs, which increase as the migrant moves to a different state or a different region of the country. These costs significantly affect estimates of the value of climate amenities.

Our results suggest that movers are willing to pay to avoid cold winter temperatures and snow. Summer precipitation, in contrast, is an amenity. Marginal willingness to pay for warmer winter temperature is statistically significant at the 5 percent level for temperatures between 10 and 43 degrees Fahrenheit, but decreases as temperature increases. Preliminary estimates indicate that households facing an average winter temperature of 37 degrees Fahrenheit are willing to pay approximately 3% of their income for an increase in average winter temperature by one degree. It is, however, likely that this captures the value of other climate amenities that are correlated with winter temperature, such as sunshine. Households are willing to pay 4% of their income to reduce winter precipitation from 5 to 4 inches, which corresponds to between 13 and 20 inches of snow.[3] Willingness to pay to raise summer precipitation is significant at the 10% level between 8 and 13 inches but, surprisingly, not at lower levels of precipitation. There is no evidence that average summer temperature plays a significant role in household migration decisions.

[3] Willingness to pay to reduce winter precipitation is significant only between 1 and 5 inches, suggesting that people wish to avoid snow rather than rainfall.

The paper is organized as follows. We briefly review the literature on valuing climate amenities in Section 2. In Sections 3 we present the household's location decision and the econometric models to be estimated. Section 4 describes the data used in our analysis. Results are presented in Section 5. Section 6 concludes the paper.

Section 2: Literature review

There are two strands of the economics literature that value climate amenities. The first uses hedonic wage and property value functions to compute marginal amenity values, following Rosen (1974) and Roback (1982). The second uses discrete models of consumer location choice.

The continuous hedonic approach, developed by Rosen (1974) and refined by Roback (1982) is based on the notion that people's preferences for climate attributes should be reflected in their location decisions, and, hence, be capitalized into wages and land values: Other things equal, workers should accept lower wages to live in more pleasant climates and should be willing to pay more for housing in more desirable climates. How, in equilibrium, property values and wages vary with climate attributes depends, however, not only on consumer preferences, but also on how climate affects firms' costs. As Roback (1982) demonstrates, equilibrium wages should unambiguously be lower and land prices higher in cities with more desirable amenities only when amenities do not directly affect firms' costs. When they do—for example, when a firm's costs are lower in a warmer climate—the impact of a warmer climate on wages is ambiguous: workers are willing to work for less in a warmer climate, but firms are willing to pay more, other things equal.[4]

Early attempts to estimate how much consumers will pay for more desirable climates relied on estimating hedonic wage and property value functions. Assuming a national labor market, wages in different cities should reflect differences in climate amenities, holding job and worker characteristic constant. The hedonic wage function relates the equilibrium wage to job characteristics, including occupation and industry; worker characteristics (e.g., education and years of experience); and locational amenities—climate, crime, air quality, proximity to the ocean. The hedonic property value function describes how, in equilibrium, housing prices vary across cities as a function of housing characteristics and locational amenities. In equilibrium, workers will select a city (a vector of amenities) so that the marginal cost of obtaining each amenity, measured in terms of wages and housing costs, just equals the value he places on the amenity.[5] The value of locational amenities is thus inferred from hedonic wage and property value functions.

Hedonic wage and property value models have been estimated by Hoch and Drake (1974); Cropper and Arriaga-Salinas (1981); Cropper (1982); Roback (1982); Smith (1983); Blomquist et al. (1988); Gyourko and Tracy (1991) and Cragg and Kahn (1999). The first three studies estimate only hedonic wage functions, while the last five estimate both wage and property value equations. As Moore (1998) and Gyourko and Tracy (1991) note, this literature suggests that climate amenities are capitalized to a

[4] Property values should, however, be unambiguously higher: both firms and workers would like to purchase land in cities with warmer climates, which should drive up land prices.
[5] Formally, marginal willingness to pay for an amenity must equal the sum of the slope of the hedonic wage function with respect to the amenity plus the slope of the hedonic property value function evaluated at the chosen amenity vector.

greater extent in wages than in property values.[6] Roback (1982), Smith (1983) and Blomquist et al. (1988) all find sunshine to be capitalized in wages as an amenity, while heating degree days are capitalized as a disamenity (Gyourko and Tracy,1991; Roback,1982, 1988).

Unfortunately, hedonic wage and property value studies have limitations that have caused them to be replaced by alternate approaches to analyzing data on location choices. One drawback of the hedonic approach is that it assumes that national labor and housing markets exist and are in equilibrium. As Graves and Mueser (1993) and Greenwood et al. (1991) point out, if national markets are not in equilibrium, inferring the value of climate amenities from hedonic wage and property value studies can lead to badly biased results. A second problem is that variables that are correlated with climate (e.g., the availability of recreational facilities) may be difficult to measure; hence, climate variables may pick up their effects. In hedonic property value studies, for example, the use of heating and cooling degree days to measure climate amenities is problematic because their coefficients may capture differences in construction and energy costs as well as climate amenities per se. A related problem in hedonic wage equations is that more able workers may locate in areas with more desirable climates. If ability is not adequately captured in the hedonic wage equation, the coefficients of climate amenities will reflect worker ability as well as the value of climate.

Cragg and Kahn (1997) were the first to relax the national land and labor market equilibrium assumption by estimating a discrete location choice model. Using Census

[6] The effect of weather variables on property values is mixed, with Blomquist et al. (1988) finding property values to be negatively correlated with precipitation, humidity and heating and cooling degree days, but Roback (1982) finding property values positively correlated with heating degree days. Gyourko and Tracy (1991) find heating and cooling degree days negatively correlated with housing expenditures, but humidity positively correlated.

data, they model the location decisions of people in the U.S. who moved between 1985 and 1990. Movers compare the utility they would receive from living in different states—which depends on the wage they would earn and on the cost of housing, as well as on climate amenities—and are assumed to choose the state that yields the highest utility. This allows Cragg and Kahn to estimate the parameters of individuals' utility functions and thus infer the rate at which they will trade income for climate amenities. Unfortunately, the empirical estimates in this study are extremely large: The authors estimate, for example, that a non-college graduate between 50 and 60 would pay over $67,000 per year for a one standard deviation increase in mean February temperature.[7]

An alternate approach to modeling the location decisions of migrants is to acknowledge that moving is costly and to explain the location decisions of all households, assuming that all households are in equilibrium, given moving costs. Bayer, Keohane and Timmins (2006) use this approach to value air pollution, modeling the moving costs of all household heads from their birthplace. We follow Bayer, Keohane and Timmins (2006) but limit our model to movers. Our attempts to model the location decisions of stayers as well as movers, discussed below, suggested to us that stayers are not in equilibrium.

Section 3: A Model of Migration Decisions

We model households who moved between 1995 and 2000 as selecting their preferred metropolitan area (MSA) from a set of 297 MSAs in the United States in 2000. Household utility depends on housing, on location-specific amenities, moving costs and

[7] This corresponds to a 10.4 degree temperature change or $6,700 for a one degree change. Annual household income is $35,000 for all movers.

on expenditure on all other goods (income minus the cost of housing). Utility maximization proceeds in two stages: for each location j the household optimally allocates its income between housing expenditure and all other goods, yielding an indirect utility function for city j. The household then chooses the location in which to live that yields the highest possible indirect utility.

Utility Maximization within Each City

Each household chooses the quantity of consumption of a numeraire good and housing to maximize its utility subject to a budget constraint. Formally, the utility maximization problem of household i in location j is:

Choose $\{C_{ij}, H_{ij}\}$ to maximize $U(C_{ij}, H_{ij}, MC_{ij}, E_j)$

subject to the budget constraint $C_{ij} + R_j H_{ij} = \sum_{m=1}^{Ni} w_{mj}$ (1)

where

m ≡ individual
i ≡ household
j ≡ location
N_i ≡ number of household members in household i
C_{ij} ≡ Consumption of a numeraire good by household i living in location j
H_{ij} ≡ Quantity of housing consumed by household i living in location j
R_j ≡ Cost of housing in location j
MC_{ij} ≡ Moving costs of household i to location j
w_{mj} ≡ Wages earned by an individual m when living in location j
E_j ≡ Vector of Amenities (e.g. climate) and disamenities (e.g. pollution, crime, etc) in location j.

Substituting the optimal values of consumption and housing expenditure, C_{ij}^* and H_{ij}^* into the utility function yields i's utility from MSA j,

$$V_{ij} = V(W_{ij}, MC_{ij}, R_j, E_j) \tag{2}$$

where, W_{ij} represents the total household wages of household i in location j.

i.e. $W_{ij} = \sum_{m=1}^{\mathrm{Ni}} w_{mj}$.

Random Utility Model (RUM) of Migration

In the migration model households select among locations based on the indirect utility they receive from each location. Using a Random Utility Model (McFadden, 1973), the indirect utility of household i from living in location j is given by:

$$V_{ij} = V(W_{ij}, MC_{ij}, R_j, E_j) + \varepsilon_{ij} \tag{3}$$

where ε_{ij} is an idiosyncratic error and V(.) is the deterministic component of the utility function. Assuming that the idiosyncratic errors are i.i.d. Type I Extreme Value, the probability of household i migrating to region j is given by the Conditional Logit Model[8]:

$$\Pr(V_{ij} \geq V_{ik}, \forall k \neq j) = \frac{e^{V(W_{ij}, MC_{ij}, R_j, E_j)}}{\sum_{k=1}^{K} e^{V(W_{ik}, MC_{ik}, R_k, E_k)}} \tag{4}$$

where K = number of alternatives.

[8] This does impose the assumption of the Independence of Irrelevant Alternatives (or IIA). However, using a more general error structure (e.g by using a nested logit model or a random parameters model) would increase computational costs.

Empirical Specification

For purposes of estimation we assume the form of the utility function is Cobb Douglas,

$$U_{ij} = C_{ij}^{\alpha_C} H_{ij}^{\alpha_H} e^{MC_{ij}} e^{g(E_j)} , \tag{5}$$

which implies that the indirect utility function is

$$V(W_{ij}, MC_{ij}, R_j, E_j) = \left(\frac{\alpha_C}{\alpha_C + \alpha_H}\right)^{\alpha_C} \left(\frac{\alpha_H}{\alpha_C + \alpha_H}\right)^{\alpha_H} W_{ij}^{\alpha_C + \alpha_H} e^{MC_{ij}} \left(\frac{1}{R_j}\right)^{\alpha_H} e^{g(E_j)} . \tag{6}$$

The form of the function g(.) depends on what is assumed about the preferences for the amenities. For example, it might be reasonable to assume that there is an optimal temperature that households prefer, which would be captured by a quadratic form for g(.). Below we present results using different functional forms for g(.). Marginal willingness to pay for an amenity by a household is given by the marginal rate of substitution between the amenity and income. For example, if we assume that $g(E_j) = \alpha_E \ln E_j$ then the MWTP of a household i for climate amenity E is $(\alpha_E / \alpha_C + \alpha_H)^* \ W_{ij} / E_j$.[9]

We follow Bayer et al. (2006) in representing moving costs as a series of dummy variables that reflect whether city j is outside of the state, Census division and/or Census region in which household i lived in 1995. Formally,

$$MC_{ij} = \alpha_{M0} d_{ij}^{State} + \alpha_{M1} d_{ij}^{Division} + \alpha_{M2} d_{ij}^{Region} \tag{7}$$

[9] In the remainder of the paper, we focus on estimating this marginal rate of substitution. Calculating a complete welfare measure would entail looking at the impact of a change in the vector of amenities on expected household utility, as is usually done in a random utility framework (Freeman, 1993).

where d_{ij}^{State} denotes a dummy variable that equals one if location j differs from the state in which household i lived in 1995, $d_{ij}^{Division} = 1$ if location j is outside of the Census Division in which household j lived in 1995, and $d_{ij}^{\mathrm{Re}gion} = 1$ if location j lies in a different Census Region than the one is which household i lived in 1995. We interpret moving costs as reflecting both the psychological and physical costs of moving.

Estimation of the Migration Equation

Previous assumptions imply that the logarithm of the systematic portion of the indirect utility function can be written as

$$\ln(V(W_{ij}, MC_{ij}, R_j, E_j))$$

$$= \alpha_C \ln(\frac{\alpha_C}{\alpha_C + \alpha_H}) + \alpha_H \ln(\frac{\alpha_H}{\alpha_C + \alpha_H}) + (\alpha_C + \alpha_H)\ln W_{ij} + MC_{ij} - \alpha_H \ln(R_j) + g(E_j) \tag{8}$$

implying that the migration equation in log form is as follows:

$$\Pr(\ln V_{ij} \geq \ln V_{ik}, \forall k \neq j) = \frac{e^{(\alpha_C + \alpha_H)\ln W_{ij} + MC_{ij} - \alpha_H \ln(R_j) + g(E_j)}}{\sum_{k=1}^{K} e^{(\alpha_C + \alpha_H)\ln W_{ik} + MC_{ik} - \alpha_H \ln(R_k) g(E_k)}} \tag{9}$$

The parameters of equation (9) are estimated in two stages. We replace all the variables that vary only by MSA by a location specific intercept A_j,

$$A_j = -\alpha_H \ln(R_j) + g(E_j) \tag{10}$$

which reduces $\Pr(\ln V_{ij} \geq \ln V_{ik}, \forall k \neq j)$ to

$$= \frac{e^{(\alpha_C+\alpha_H)\ln W_{ij}+MC_{ij}+A_j}}{\sum_{k=1}^{K} e^{(\alpha_C+\alpha_H)\ln W_{ij}+MC_{ij}+A_j}} \quad . \qquad (11)$$

Equation (11) is estimated via maximum likelihood techniques, with W_{ij} and R_j replaced by their estimated values. This gives estimates of the location specific intercepts A_j.

In the second stage, the MSA-specific fixed effects, A_j are regressed on R_j and location specific amenities to obtain the parameters of equation (10).

In the second stage of the estimation, the left hand side of equation (10) represents the average indirect utility from MSA j after controlling for household income and moving costs. Because living costs are likely to be correlated with the error term, α_H is set equal to 0.25, which is the median share of income spent on housing in the sample, and $\alpha_H R_j$ is added to the dependent variable. Thus, in the second stage, we estimate the following equation:

$$(A_j + 0.25\,R_j) = g(E_j) + \eta_j \qquad (12)$$

Predicting Wages and Housing Costs

To estimate the migration equation requires information on the wages that a household would earn and the cost of housing in all possible locations; however, wages and housing costs are observed only in the household's chosen location. We therefore estimate these for all possible locations.

To predict $W_{ij} \forall j$ we estimate an hedonic wage equation for each MSA of the form

$$\ln(WageRate_i) = \beta_0 + \beta_D DemographicCharacteristics + \beta_{ED} EducationVariables + \beta_{EXP} ExperienceVariables + error \tag{13}$$

The dependent variable in this equation is the log of the hourly wage rate of each individual. Equation (13) is estimated using all full-time workers in the 2000 PUMS, excluding self employed individuals and persons working in agriculture, farming, fishing or forestry.[10] Military personnel (those who were enrolled from 1995 to 2000) and handicapped individuals (defined as persons having difficulty working) were also excluded from the sample, as were workers who worked more than 60 hours per week to avoid including individuals who have multiple jobs.

The coefficients from the hedonic equations are used to calculate the wage rates for each individual in each location. We use the product of these estimated wage rates and the total hours each individual worked in a year to estimate the individual's wages in all locations. Summing these over all individuals in each household, we obtain household wages for all locations. This bypasses the need to model labor-leisure choice decisions by making the simplifying assumption that individuals work the same number of hours and number of weeks in any location.

In order to impute the housing costs that each household would face in each location, we estimate a cost of housing index for each MSA (i.e. $R_j \forall j$) based on a national hedonic housing market equation. The national hedonic housing equation

[10] Full-time workers are defined as those persons who worked at least 30 hours per week and 30 weeks per year.

controls for dwelling characteristics and includes a dummy variable for each MSA. If we were to estimate a separate housing equation for each metropolitan area, we would have to make an assumption about the housing bundle consumed by each household in each area in order to predict housing expenditure for a household in each city. The housing price index approach is much cleaner.

Ideally we would like to estimate separate hedonic equations for the owner and rental markets since supply conditions in the two markets differ; however, this would necessitate predicting the probability that a household will buy or rent when moving to a new location. We therefore ignore the rent/own distinction and estimate a national hedonic housing market equation that pools observations from the owner and rental markets. To make the cost of housing comparable across both markets, the cost of owning a home is calculated as the sum of mortgage payments (using an interest only/fixed rate mortgage), property taxes and insurance.[11] Utility costs are added to both the costs of owning a home and to rents because a major portion of utility costs are due to heating and cooling requirements. Such costs need to be separated from climate amenities.

The dependent variable in the housing model is the logarithm of user cost—the sum of the monthly mortgage payment or rent, utilities, taxes and insurance. Explanatory variables include dummies describing the age and size of the house, whether it was owned or rented, had a kitchen and had indoor plumbing. The MSA dummies from this equation constitute the $\{R_j\}$. The sample used to estimate this equation consists of all houses excluding farms, mobile homes and boats occupied by households in the PUMS.

[11] User costs should include expected house price appreciation; however, this was excluded because it was difficult to calculate.

$$\ln(usercost_i) = R_0 + R_{OWN} OwnershipDummies + R_{BR} BedroomDummies$$
$$+ R_R RoomDummies + R_{KIT} KitchenDummy + R_P PlumbingDummy$$
$$+ R_{ACRE} Acreagedummies + R_{AGE} AgeofStructureDummies$$
$$+ R_{UNITS} UnitsStructureDummies + R_{MSA} MSADummies + error \quad (15)$$

It should be noted that amenities do not enter either the wage or the housing hedonic equations. The purpose of these equations is to predict earnings opportunities and housing costs facing the household in each city. The fact that location-specific amenities are capitalized into housing costs is reflected in equation (10).

Section 4: Data

The data used to estimate our migration model come from the 5% Public Use Microdata sample (PUMS) of the 2000 Census, as well as other publicly available data sources. The PUMS contains data on the locations of households in 2000 and 1995 and on household characteristics. It also contains information on the labor force participation, hours and earnings of individuals, as well as the occupation and the industry in which they worked. These data are used to estimate hedonic wage equations for 297 MSAs. Information housing costs and characteristics, for estimation of the housing hedonic equation, are also taken from the PUMS. Data on location-specific amenities, including climate, air pollution, and quality of transportation and education services, come from a variety of sources. This section briefly discusses these data.

Migrant Households and Migration Patterns

The PUMS contains information on over 5.6 million households. Tables 1 and 2 below describe the households who changed MSAs between 1995 and 2000, for whom both the origin and destination MSA can be identified.[12] Of these 441,393 households, 60.8% moved to a different state and 46.9% moved to a different Census division. Thirty-six percent moved to a different Census region. Table 1 shows the origin and destination of households by Census region. Thirty-two percent of the households who moved between 1995 and 2000 were living in the South in 1995; 28% were living in the West. Over 70% of these households moved within the region in which they lived in 1995. In contrast, only about half of the movers who lived in the Northeast or Midwest in 1995 remained in their region of origin. On net, household left the Northeast and Midwest for the South and West, a pattern that began after the Second World War and is predicted to continue at least through 2030.

Table 2 compares the characteristics of movers and stayers. Households who moved are, on average, smaller and have fewer children than households who did not move. A higher proportion of households that moved are male-headed, and the head of household is better educated than is the case for households that did not move.

Amenity Variables

The amenity variables used in the second stage of the model are summarized in Table 3 and described briefly below.

[12] Of the 5.66 million households in the PUMS, 1.53 million lived in named MSAs in both 1995 and 2000. Twenty-eight percent of these households changed location between 1995 and 2000. A household was considered to have moved if the head of household moved.

Climate Variables

Previous studies have used a variety of climate variables, including mean January temperature, mean July temperature, average January precipitation, average July precipitation, annual heating and cooling degree days, humidity and percent possible sunshine. Below we focus on mean temperature and precipitation, measured for the winter (December-February) and summer (June-August) seasons. All variables are climate normals: the arithmetic mean of a climatological element computed for the period 1971-2000.[13] Attempts to include temperature and precipitation for the fall and spring are hampered by multicollinearity.

We have also experimented with heating and cooling degree days and temperature bins.[14] Degree days are highly correlated with average temperature on a monthly or seasonal basis. For example, January Heating Degree Days (HDD) = 2015 – (31*Average January Temperature) provided average temperature is less than 65 degrees for all days in January. It is therefore a matter of taste whether to use average temperature or degree days. We use the former for ease of interpretation. We could also use annual heating and cooling degree days, but this eliminates seasonal distinctions. The same is true of the number of days each year in various temperature bins (e.g., the number of days in 5° Fahrenheit temperature bins).

---

[13] The data are available online at http://nndc.noaa.gov/?http://lwf.ncdc.noaa.gov/servlets/ACS and the relevant documentation is at http://www1.ncdc.noaa.gov/pub/data/documentlibrary/tddoc/td9641f.doc .

[14] Heating and cooling degree days are computed by the National Climatic Data Center using the average of the high and low temperature for a day. If this is greater than 65° F, it results in (Average temperature - 65) cooling degree days. If the average temperature is less than 65 degrees it results in (65 - Average temperature) heating degree days.

Other aspects of climate which are potentially relevant to households are average wind speed, humidity and the amount of possible sunshine.[15] The latter is defined as the total time that sunshine reaches the surface of the earth expressed as the as the percentage of the maximum amount possible from sunrise to sunset with clear sky conditions. Unfortunately, data on wind speed, humidity and sunshine are available for fewer than half of the MSAs in the dataset.

Air Quality and Crime

We measure air pollution using data on ambient particulate matter (PM10 and PM2.5), and a variable indicating whether an MSA is out of attainment with any of the National Ambient Air Quality Standards (NAAQS). PM10 and PM2.5 are both visible to the human eye and have significant negative health effects. We use both average annual ambient concentrations and the 95th percentile of annual readings for the year 2000.[16] The NAAQS dummy equals 1 if any county in an MSA is out of attainment with the NAAQS for any of the criteria pollutants.

The crime variable reported below, from the Uniform Crime Reporting (UCR) Program of the Federal Bureau of Investigation, combines both violent and property crimes. Property crimes include burglaries, larcenies, motor vehicle thefts, and arsons. Violent crimes include murders, rapes, robberies, and aggravated assaults. These are summed and expressed as a rate by dividing by population. High correlation between the

[15] This is publicly available at http://www1.ncdc.noaa.gov/pub/data/ccd-data/ and the relevant documentation is at (http://www1.ncdc.noaa.gov/pub/data/ccd-data/CCD_2006.pdf)

[16] The USEPA's BenMAP (Abt 2005) was used to convert monitor level data to air quality grids for each MSA. From these grids we computed population-weighted annual average PM10 and PM2.5 levels.

property and violent crime rates prevented their separate inclusion in the migration models.

Amenity Data from the Places Rated Almanac

A key difficulty in valuing climate amenities is to separate their effects from endogenous amenities that are likely to be correlated with climate: Recreational opportunities, for example, are likely to be more numerous in cities with milder climates. We use the *Places Rated Almanac* to capture recreation and other amenities that may be correlated with climate. This publication contains indices of the quality of education, transportation, recreation and health services and the arts for all MSAs in 2000. For transportation, the factors used to rate each MSA are its supply of public transit, average commute time, and connectivity with other metro areas via national highways, scheduled air service, passenger rail service, and nearness to all other metropolitan areas. The education index reflects School Support (measured by the average pupil-teacher ratio and percent of funding received from local sources, Library Popularity (the circulation rate added to number of volumes divided by population), College Enrollment and College Options (the variety of higher education institutions in the MSA). (A detailed description of the indices may be found in *Places Rated Almanac* (2000).)

Population Density, Proximity to the Coast, Regional Dummies

Population density (or, alternately, population) is included to capture amenities not specifically captured by the *Places Rated Almanac*. The coastal dummy indicates that the MSA is located on an ocean, gulf or the Great Lakes. Dummy variables for the four Census regions (or, alternately, the nine Census divisions) are included to capture regional variation in amenities not explicitly controlled for, as well as differences in the cost of non-housing goods. A map of the US showing the different Census Regions and Divisions is shown in Figure 1.

Section 5: Estimation Results

Hedonic Wage Equations

The results of the hedonic wage equations are summarized in the Appendix. Since the wage regressions are estimated separately for each MSA, the mean and standard deviation of the 297 coefficients for each explanatory variable are presented in Table A.1. Most variable are significant at the 5% level for all MSAs. Older workers earn more, but the age premium declines with age, as expected. Married individuals and males earn more than single persons and females. Good English-speakers earn more than people who have difficulty with the language, and Hispanics earn less than non-Hispanics. There are positive returns to education. Occupation dummies also have the expected signs, i.e., occupations requiring more education and/or white collar occupations are associated with higher wages. What is notable, however, is that the returns to different occupations and industries vary significantly across MSAs, suggesting that the assumption of a national labor market, made earlier hedonic studies, is inappropriate.

Hedonic Housing Market Equation

The results of the hedonic housing equation are also presented in the Appendix. An owner-occupied house carries a premium. Houses with greater numbers of rooms and bedrooms are worth more than houses with fewer rooms. Houses on smaller acreage are worth less than houses on larger lots. Older houses have lower value than newer houses. These variables are all statistically significant at the 5% level. Ninety three percent of the MSA specific dummy variables are statistically significant at the 5% level. The MSA specific dummies, which represent housing cost indices, seem reasonable. For example, Boston has a higher index than Seattle, which is in turn more expensive than Washington DC. The MSAs in California, New York and New Jersey have very high costs of living. The 20 most expensive and 20 least expensive MSAs are listed in Table 4.

Results from the First Stage of the Migration Equation

We begin by presenting the results of estimating equation (11) using households who moved between 1995 and 2000. A household is considered to have moved if the head of the household moved. Households with the head serving in the military were deleted from the sample because their location choices were not likely to have been voluntary. Also, those working in farming, fishing and forestry as well as those who were self-employed were deleted as it was difficult to predict their wages in each MSA. If households reported some members to have been in the labor force but reported zero household wages, they were deleted from the sample due to likely reporting errors.

To make the analysis computationally tractable, a 20% random sample of households was used in estimating the migration equation, yielding 75,293 households. Following McFadden (1978) the choice set for each household included the MSA the household chose and 19 other randomly selected MSAs. This random sampling of alternatives produces consistent estimates when the uniform conditioning property holds (McFadden 1978).

Table 5 presents three sets of results for the migration equation. In the first specification presented below (specification 0), the only independent variables are the log of household wages and the location specific dummies (the $\{A_j\}$). Moving cost dummies are included in the second specification (specification 1). The coefficient on the log of household earnings is 0.830 in specification 0 and 0.972 in specification 1. In specification 1, the moving cost dummies are statistically significant at conventional levels and have negative coefficients: changing states reduces utility, as does changing Census divisions and Census regions. Henceforth, specification 1 is referred to as the "base case." Specification 2 is identical to specification 1, but uses a choice set of size 40 (the chosen MSA plus 39 randomly selected MSAs). Results are almost identical to those in the base case.

Comparing Movers and Stayers

As Table 2 illustrates, movers differ in terms of observable characteristics from stayers. This raises two questions: Do stayers have the same preferences as movers? Can the preferences of stayers be estimated based on their location choices? For the latter to be possible, it must be the case that stayers are in equilibrium. While it is difficult formally to test the hypothesis that stayers are in equilibrium, some information can be provided by estimating the migration equation using both movers and stayers and comparing the results with estimates using movers only.

The results of estimating model for both movers and stayers are presented in Table 6 (specification 3), based on a 5% random sample from the PUMS. Movers constitute 28% of the sample. The coefficient on the wage is 0.76 as compared to 0.97 for the movers-only sample. The coefficients of the moving cost variables are also very different: they imply that a household would give up five dollars in wages in a new location for every dollar currently earned to avoid leaving the state in which they lived in 1995. This is a much larger rate of substitution than in specification 1 and suggests that stayers may not be in equilibrium.

Following Bayer, Keohane and Timmins (2006), we also define moving costs relative to the state of birth. In models 4 and 5 of Table 6 each moving cost dummy equals 1 if MSA j is located in a different state (Census division, region) than the one in which the head of household was born. In the movers-only sample (specification 4) the coefficient on the log of earnings is 0.838. The coefficients on the moving costs are similar to those obtained from specification 1. The correlation between the estimated location specification intercepts and those in the base case is 0.979. Thus, the two models using a sample of movers yield very similar results and suggest that the estimates are robust to specification.

The model estimated with a sample of movers and stayers and using moving cost dummies calculated from birthplace (specification 5) yields a coefficient of 0.239 on the log of wages. Given that 28% of the sample consists of movers, this suggests that the coefficient on wages for stayers is approximately zero.[17] A comparison of specifications 3 and 5 reveals that the results for the movers and stayers sample are very sensitive to

[17] The coefficient on the log of wages for the sample using both movers and stayers can be interpreted as a weighted mean of the coefficients for movers and stayers, implying (0.28 * 0.97) + (0.72 * Stayer Coefficient) = 0.239.

specification. Though there is no clear test as to whether stayer households are in equilibrium, it is reasonable to conclude that the first stage results for movers and stayers seem unstable and cannot be used to estimate preferences for amenities. We therefore estimate the preferences of movers for locational amenities using specification 1.

MSA Dummies

The MSA dummies estimated in stage one (the $\{A_j\}$) can be interpreted as Quality of Life Indices: They represent the average utility obtained from location-specific amenities net of housing costs. Tables 7 and 8 list the top 20 and bottom 20 MSAs, respectively, from specifications 1 and 2. The rankings of cities based on the two models are very close.

Results from the Second Stage of the Migration Equation

The second stage of the estimation entails regressing of the MSA-specific fixed effects on housing costs and amenities (equation (10)). Because living costs are likely to be correlated with the error term η_j, α_H, the fraction of income spent on housing, is set equal to 0.25 (which is the median share of income spent on housing in my sample) and $\alpha_H R_j$ is added to the dependent variable (equation (12)).

Table 9 present two sets of specifications for the second stage, using the model with movers only and moving costs calculated based on 1995 location (the base case). The first model (model 1 in the table) includes the Census region dummies while the second model includes the Census division dummies.[18] Results with division dummies

[18] Variation of amenity values within regions and divisions is shown in Tables (A4.2.4) and (A4.2.5) of Sinha (2008).

generally show smaller impacts of climate on migration decisions and are more conservative than estimates with region dummies. This is because temperature and precipitation may pick up differences in non-housing costs of living when only regional dummies are included.

The second stage models fit well ($R^2 \approx 0.76$-0.77) and most variables are significant at conventional levels, with expected signs. Exceptions to this include air pollution, which has a positive sign and the health care index from the *Places Rated Almanac*, which also has the wrong sign, but is statistically insignificant. Pollution levels are likely to be correlated with local economic activity and are likely picking up this effect. We demonstrate below that estimated climate effects are robust to the representation of air pollution.

The climate variables included in the second stage regressions are average winter and summer temperature and precipitation. The squares of these variables are included to allow for preferences consistent with an optimal value for each of the climate variables. Figures 2 through 5 display the estimated parabolas for all four climate variables corresponding to model 2, with colors to indicate the ranges of temperature and precipitation for which marginal effects are significant at the 5 and 10 percent levels. Table 9 indicates that winter temperature increases utility up to 53 degrees Fahrenheit (model 1) and 59 degrees Fahrenheit (model 2), although marginal effects are significant only up 43 degrees Fahrenheit (see Figure 2). The corresponding numbers for summer are 87 and 74 degrees Fahrenheit; however, the summer temperature variables are not significant at observed temperature levels in either model.

The marginal effects of the climate variables, calculated at sample means, are presented, together with their t-statistics, in Table 10. The table and Figure 2 indicate that winter temperature is an amenity, with marginal effects that are significant at the 5% level of higher between temperatures of 10 and 43 degrees. The results also imply that households value higher summer precipitation in the range of 8 to 13 inches. (Note that mean summer precipitation is approximately 11 inches.) The disutility attached to winter precipitation is statistically significant only at levels less than 5 inches (see Figure 4). Low levels of winter precipitation correspond to snow, hence this suggests that it is snow rather than rainfall which is a disamenity. Summer temperature does not have a significant marginal effect in either specification.[19] This is consistent with the observation of Cragg and Kahn (1999) that air-conditioning has reduced the disamenity impacts of higher summer temperatures.

The marginal effects reported in Table 10 are robust to alternate specifications of the non-climate dummy variables in the second stage, and also to the fraction of income spent on housing. Table 11 reports marginal effects for the model with Census division dummies and alternate specifications of non-climate amenities. These include (1) the use of annual average PM2.5 and NAAQS non-attainment dummy in lieu of PM10; (2) the use population instead of population density; (3) the use of separate crime variables for property and violent crimes; and (4) the use of three coastal dummies (for the ocean, gulf and the Great Lakes). The marginal effects of winter temperature and summer precipitation are robust to the various specifications: the marginal effect of winter temperature (evaluated at mean winter temperature) ranges from 0.027 to 0.033; the

[19] These results are robust even using moving costs calculated from birthplace. The marginal effects are presented in Table A5.7 in Sinha (2008).

marginal effect of summer precipitation from 0.032 to 0.036. Winter precipitation remains marginally significant with a coefficient of approximately -0.02. The only case in which summer temperature approaches statistical significance (t-ratio = -1.45) is when population replaces population density. Results are also robust to using alternate values of α_H (0.20 and 0.30), as shown in Table 12.

Marginal Willingness to Pay for Climate Amenities

What do the estimates in Table 10 imply about a migrant household's marginal willingness to pay for climate amenities? We present illustrative estimates of the marginal rate of substitution between earnings and winter temperature based on the systematic portion of the household's utility function.[20] Table 10 implies that a household facing an average winter temperature of 37 degrees is willing to pay about 2.99% of their annual income to raise it by a degree. For example, a household with mean earnings of 45,000 dollars would be willing to pay 1,500 dollars to raise average winter temperature from 37 to 38 degrees. Model 2 of Table 9 implies that households are willing to pay 3.86% of their annual income to raise summer precipitation by an inch from a level of about 11 inches and 4.22% to lower winter precipitation from 5 to 4 inches. (All calculations are based on the model with Census divisions.)

These are admittedly large values, and it is likely that our climate variables, as currently specified, are capturing other climate and spatially varying amenities, rather than temperature and precipitation per se. We are currently expanding the set of climate

[20] Calculating a complete welfare measure would entail looking at the impact of a change in the vector of amenities on expected utility.

amenities included in the model, as well as other spatially varying amenities (e.g., outdoor recreation opportunities) that are correlated with climate.

Section 6: Conclusions and Future Research

There is a large literature that has attempted to value climate amenities or to estimate the role that they play in migration decisions in the United States. This paper contributes to this literature by modeling the location choices of households who changed MSAs between 1995 and 2000. The results provide estimates of the rate at which movers substitute income for temperature and precipitation—of marginal willingness to pay for changes in these climate variables. The results could also be used to simulate the impact of a counterfactual climate scenario on the migration patterns of households in the U.S.

Two questions arise when estimating the preferences of movers for climate amenities. Do stayers have the same preferences as movers? Can the preferences of stayers be estimated based on their location choices? For the latter to be possible, it must be the case that stayers are in equilibrium. While it is difficult formally to test this hypothesis, some information can be provided by estimating the migration model using both movers and stayers and comparing the results with estimates using movers only. When the migration model is estimated for all households in the PUMS sample, including those who did not change MSAs between 1995 and 2000, the low coefficient on wages in the first stage results suggests that stayers are not in equilibrium. Thus, we focus on results from the movers sample.

Our results suggest that movers are willing to pay to avoid cold winter temperatures and snow. Summer precipitation, in contrast, is an amenity. Marginal willingness to pay for warmer winter temperature is statistically significant at the 5 percent level for temperatures between 10 and 43 degrees Fahrenheit, but decreases as temperature increases. Preliminary estimates indicate that households facing an average winter temperature of 37 degrees Fahrenheit are willing to pay approximately 3% of their income for an increase in average winter temperature by one degree. It is, however, likely that this captures the value of other climate amenities that are correlated with winter temperature, such as sunshine. It may also capture recreation opportunities. Households are willing to pay 4% of their income to reduce winter precipitation from 5 to 4 inches, which corresponds to between 13 and 20 inches of snow. Willingness to pay to raise summer precipitation is significant at the 10% level between 8 and 13 inches but, surprisingly, not at lower levels of precipitation. There is no evidence that average summer temperature plays a significant role in household migration decisions.

We are currently expanding the set of amenities included in the model, including climate amenities, and are also examining the sensitivity of model results to the specification of moving costs. Table 1 for example, suggests that it is more likely that a household leaving the Northeast migrates to the South than to the West. This is not adequately captured by the current set of moving cost dummies. Once modified, the model could be used to predict how different climate change scenarios might affect migration patterns in the US.

References

Abt Associates Inc., BenMAP, *The Environmental Benefits Mapping and Analysis Program: User's Manual* (June, 2005) *Prepared for* Office of Air Quality Planning and Standards U.S. Environmental Protection Agency Research Triangle Park, NC

Bayer, Patrick; Keohane, Nathaniel and Timmins, Christopher. "Migration and Hedonic Valuation: The Case of Air Quality", *NBER Working Paper*, No. 12106 (March, 2006)

Blomquist, Glenn C.; Berger, Mark C.; Hoehn, John P. "New Estimates of Quality of Life in Urban Areas", *The American Economic Review,* Vol. 78, Issue 1, March (1988): 89-107.

Cragg, M. and Kahn, Matthew. "New Estimates of Climate Demand: Evidence from Location Choice." *Journal of Urban Economics ,* Vol. 42, (1997): 261-284.

Cragg, M. and Kahn, Matthew. "Climate Consumption and Climate Pricing from 1940 to 1990." *Regional Science and Urban Economics ,* Vol. 29, (1999): 519-539.

Cropper, M.L., 1981: The value of urban amenities. *Journal of Regional Science,* **21(3),** 359-374.

Cropper, M.L. and Arriaga-Salinas A.S. "Inter-city Wage Differentials and the Value of Air Quality" *Journal of Urban Economics*, Vol. 8 (1980): 236-254.

Graves and Mueser, "The Role of Equilibrium and Disequilibrium in Modeling Regional Growth and Decline: a Critical Reassessment", *Journal of Regional Science*, Vol. 33, No. 1 (1993): 69-84

Greenwood, Michael J.; Hunt, Gary L.; Rickman, Dan S.; Treyz George I. "Migration, Regional Equilibrium and the Estimation of Compensating Differentials." *The American Economic Review*, Vol. 81, Issue 5, Dec (1991):1382-1390.

Gyourko, J. and Tracy, J. "The Structure Of Local Public Finance And The Quality Of Life", *Journal of Political Econoour*, **99**, (1991):774:806

Hoch, Irving and Judith Drake, 1974: Wages, climate, and the quality of life. *Journal of Environmental Economics and Management,* **1,** 268-296.

McFadden, D. "Conditional Logit Analysis of Qualitative Choice Behavior," in: P. Zarembka, ed., *Frontiers of Econometrics*. (1973) New York: Academic Press.

McFadden, D. Modeling the choice of residential location, in: A. Karlqvist, L. Lundquist, F. Snickars, J. Weibull (Eds.), Spatial Interaction Theory and Planning Models, Amsterdam, North Holland, 1978.

Moore, Thomas Gale. "Health and Amenity Effects of Global Warming." *Economic Inquiry*, Vol. 26, July (1998):23-41.

Roback, Jennifer. "Wages, Rents, and the Quality of Life" *The Journal of Political Econoour* Vol. 90, Issue 6, Dec. (1982): 1257- 1278.

Roback, Jennifer. "Wages, Rents, and Amenities: Differences among Workers and Regions" *Economic Inquiry*, Vol. 26, No. 1, Jan (1988):23-41

Rosen, Sherwin. "Hedonic prices and implicit markets: Product differentiation in pure competition." *Journal of Political Economy,* Vol. 82, (1974): 34-55.

Savageau, David and Ralph D'Agostino. Places Rated Almanac: Millennium Edition, (2000) Hungry Minds Inc., New York, NY.

Sinha, Paramita. *The Value of Climate Amenities: A Disequilibrium Approach.* Ph.D. Dissertation, University of Maryland, 2008.

Smith, V.K., 1983: The role of site and job characteristics in hedonic wage models. *Journal of Urban Economics,* **13(3),** 296-321.

Table 1: Origin and Destination of Migrants by Census Region

Region (1995)	Region (2000)				Total
	Midwest	Northeast	South	West	
Midwest	38865 (8.81%)	5129 (1.16%)	20905 (4.74%)	13176 (2.99%)	**78075 (17.69%)**
Northeast	5230 (1.18%)	55513 (12.58%)	29725 (6.73%)	10223 (2.32%)	**100691 (22.81%)**
South	11712 (2.65%)	11906 (2.7%)	99761 (22.6%)	17259 (3.91%)	**140638 (31.86%)**
West	7707 (1.75%)	5831 (1.32%)	18663 (4.23%)	89788 (20.34%)	**121989 (27.64%)**
Total	**63514 (14.39%)**	**78379 (17.76%)**	**169054 (38.3%)**	**130446 (29.55%)**	**441393**

Table 2[21]: Descriptive Statistics of Migrants vs. Non Migrants

	Variable	Movers (N=441393)	Stayers (N=1083986)
Gender of head of household (proportions)	Male	64.13	60.39
Race of head of household (proportions)	White Black Other	75.9 11.03 13.07	73.04 14.95 12.01
Marital Status of head of household (proportions)	Married	46.36	47.12
Education of head of household (proportions)	No high school High school Some college College graduate Postgraduate education	10.71 17.83 34.19 23.35 13.92	19.25 25.49 30.41 16.39 8.46
Age of head of household (Mean)	Age	38.44	42.88
Household Wage Earnings (Mean)	Sum of the wage earnings of all household members	44870.83	43863.29
Total Household Income (Mean)	Sum of wage ,business and farm incomes and income from other sources [22] of all household members	63578.73	56857.41

[21] There are 5,663,214 households in the PUMS data. We know the MSAs that households lived in 1995 and 2000 for 26.9% of these households (1,525,379 households). For the remaining households, we do not have values for the MSA variable. This may be because these were households who did not live in MSAs in either of the two years, migrated to the US from abroad or we have missing values for either of the two years.

[22] Income from other sources would include Social Security income, welfare (public assistance) income, Supplementary Security income, interest, dividend, and rental income, retirement income and other income.

Size of household	1 member 2 members 3 members 4 members More than 4 members	39.85 27.37 13.22 11.41 8.15	30.06 26.59 16.87 14.68 11.8
Number of children in the household	0 children 1 child 2 children 3 children 4 children >4 children	68.4 13.31 11.68 4.68 1.39 0.54	54.67 18.98 16.41 6.85 2.14 0.95

Table 3. Descriptive Statistics of Amenities in the Migration Model

Variable	N	Mean	Std Dev	Minimum	Maximum	Median
WINTER_TEMP	295	37.177	12.066	9.442	67.922	34.805
SUMMER_TEMP	295	73.346	5.729	60.848	89.733	72.547
SUMMER_CDD	295	279.999	151.559	32.005	760.000	245.987
WINTER_HDD	295	844.536	346.832	68.333	1670.550	908.591
WINTERPR	295	9.402	4.971	1.500	28.084	9.206
SUMMERPR	295	11.029	4.981	0.440	23.300	11.954
ANNUAL_CDD	295	1261.240	939.873	111.783	4171.000	931.000
ANNUAL_HDD	295	4660.010	2188.000	240.667	9863.630	5017.000
ANNUAL_PRCP	295	40.723	13.592	5.080	66.747	43.218
DAYS WITH AVG TEMPERATURE <35	293	48.212	40.715	0.000	146.629	45.329
DAYS WITH AVG TEMPERATURE > 75	293	67.708	53.774	0.600	237.273	50.314
TRANSPORTATION	295	50.354	29.199	0	100	50.420
EDUCATION	295	51.015	29.182	0	100	50.990
ARTS	295	51.021	28.825	0	100	51.000
HEALTHCARE	295	48.418	28.696	0	98.3	48.440
RECREATION	295	52.586	28.658	0	100	53.540
TOTAL CRIME RATE	290	0.043	0.015	0.0019744	0.0890493	0.0417917
MSA OUT OF ATTAINMENT WITH NAAQS	297	0.199	0.400	0	1	0
MEAN PM 2.5	295	12.914	2.879	5.382	19.535	12.947
95TH PERCENTILE OF PM 2.5	295	27.063	6.547	9.389	58.177	27.261
PM 10 (MEAN)	295	23.503	4.647	10.930	44.384	23.315
PM 10(95TH PERCENTILE)	295	44.824	10.038	19.124	96.148	43.680
POPULATION DENSITY PER SQUARE MILE	297	471.266	970.289	5.400	13043.600	255.100
POPULATION	297	747077.67	1191629.06	101541	9519338	341851
MSA ON COAST	297	0.313	0.465	0	1	0
MSA ON GREATLAKES	297	0.064	0.245	0	1	0
MSA ON PACIFIC	297	0.067	0.251	0	1	0
MSA ON ATLANTICGULF	297	0.182	0.386	0	1	0
NORTHEAST	297	0.178	0.384	0	1	0
MIDWEST	297	0.246	0.431	0	1	0
WEST	297	0.199	0.400	0	1	0
SOUTH	297	0.377	0.485	0	1	0
NEW ENGLAND	297	0.064	0.245	0	1	0
MIDDLE ATLANTIC	297	0.114	0.319	0	1	0
EAST NORTH CENTRAL	297	0.175	0.381	0	1	0
WEST NORTH CENTRAL	297	0.071	0.257	0	1	0
SOUTH ATLANTIC	297	0.185	0.389	0	1	0
EAST SOUTH CENTRAL	297	0.067	0.251	0	1	0
WEST SOUTH CENTRAL	297	0.125	0.331	0	1	0
MOUNTAIN	297	0.067	0.251	0	1	0
PACIFICDIV	297	0.131	0.338	0	1	0

Table 4. Most Expensive and Least Expensive Cities

20 Most Expensive MSAs		20 Least Expensive MSAs	
Ranking	**Name of MSA**	**Ranking**	**Name of MSA**
1	San Francisco-Oakland-Vallejo, CA	297	McAllen-Edinburg-Pharr-Mission, TX
2	San Jose, CA	296	Johnstown, PA
3	Stamford, CT	295	Gadsden, AL
4	Santa Cruz, CA	294	Anniston, AL
5	Nassau Co, NY	293	Brownsville-Harlingen-San Benito, TX
6	Oakland, CA	292	Dothan, AL
7	Santa Barbara-Santa Maria-Lompoc, CA	291	Joplin, MO
8	Bergen-Passaic, NJ	290	Alexandria, LA
9	Salinas-Sea Side-Monterey, CA	289	Sumter, SC
10	Orange County, CA	288	Danville, VA
11	Santa Rosa-Petaluma, CA	287	Florence, AL
12	Danbury, CT	286	Hattiesburg, MS
13	Honolulu, HI	285	Laredo, TX
14	Ventura-Oxnard-Simi Valley, CA	284	Fort Smith, AR/OK
15	New York-Northeastern NJ	283	Terre Haute, IN
16	Boston, MA	282	Monroe, LA
17	Los Angeles-Long Beach, CA	281	Beaumont-Port Arthur-Orange,TX
18	Newark, NJ	280	Shreveport, LA
19	Middlesex-Somerset-Hunterdon, NJ	279	Decatur, AL
20	San Diego, CA	278	Houma-Thibodoux, LA

Table 5. First Stage Estimates

Variable	Specification 0		Specification 1 (Base Case)		Specification 2	
	Movers with 20 MSAs in Choice Set and Without Moving Costs		Movers with 20 MSAs in Choice Set and Moving Costs		Movers with 40 MSAs in Choice Set and Moving Costs	
	Coefficient	t-statistic	Coefficient	t-statistic	Coefficient	t-statistic
Log(household wages) ($\alpha_C + \alpha_H$)	0.8299	17.34	0.9720	18.46	0.9952	19.94
State dummy (α_{Mo})			-1.9865	-134.08	-1.9385	-142.60
Division dummy (α_{M1})			-0.5239	-30.25	-0.5185	-31.60
Regional dummy (α_{M2})			-0.6895	-48.20	-0.6865	-50.09
Number of Observations	75293		75293		75293	
Log Likelihood	-183910		-143768		-190807	
Number of Iterations	56		100		100	

Table 6. First Stage Estimates (Comparison with Other Models)

Variable	Specification 1 (Base Case)		Specification 3		Specification 4		Specification 5	
	Movers with Moving Costs Calculated from Location in 1995		Movers and Stayers with Moving Costs Calculated from Location in 1995		Movers with Moving Costs Calculated from Birthplace		Movers and stayers with Moving Costs Calculated from Birthplace	
	Coefficient	t-statistic	Coefficient	t-statistic	Coefficient	t-statistic	Coefficient	t-statistic
Log(household wages) ($\alpha_C + \alpha_H$)	0.9720	18.46	0.7629	9.15	0.8384	16.38	0.2387	3.84
State dummy (α_{Mo})	-1.9865	-134.08	-4.0038	-154.7	-2.1125	-131.98	-2.9306	-154.60
Division dummy (α_{M1})	-0.5239	-30.25	-0.6155	-18.51	-0.6045	-32.07	-0.7745	-32.65
Regional dummy (α_{M2})	-0.6895	-48.20	-0.6385	-22.85	-0.5264	-33.43	-0.4296	-21.32
Number of Observations	75293		66864		75293		66864	
Log Likelihood	-143768		-57023		-150960		-104018	
Number of Iterations	100		92		103		123	

Table 7. Top 20 Cities According to the Quality of Life Indices[23]

Rank	Specification 1 (Base Case) (Movers w/ MC)	Specification 2 (Movers w/ MC) Choice Set =40 MSAs
1	Phoenix, AZ	Phoenix, AZ
2	Atlanta, GA	Atlanta, GA
3	Washington, DC/MD/VA	Washington, DC/MD/VA
4	Las Vegas, NV	Las Vegas, NV
5	Chicago-Gary-Lake, IL	Chicago-Gary-Lake, IL
6	Boston, MA	Boston, MA
7	Tampa-St. Petersburg-Clearwater, FL	Tampa-St. Petersburg-Clearwater, FL
8	Los Angeles-Long Beach, CA	Los Angeles-Long Beach, CA
9	New York-Northeastern NJ	Denver-Boulder-Longmont, CO
10	Denver-Boulder-Longmont, CO	Dallas-Fort Worth, TX
11	Dallas-Fort Worth, TX	New York-Northeastern NJ
12	Philadelphia, PA/NJ	Philadelphia, PA/NJ
13	Orlando, FL	Orlando, FL
14	Raleigh-Durham, NC	Seattle-Everett, WA
15	Seattle-Everett, WA	Raleigh-Durham, NC
16	Charlotte-Gastonia-Rock Hill, SC	Houston-Brazoria, TX
17	Houston-Brazoria, TX	Charlotte-Gastonia-Rock Hill, SC
18	Portland-Vancouver, OR	Portland-Vancouver, OR
19	Baltimore, MD	Baltimore, MD
20	West Palm Beach-Boca Raton-Delray Beach, FL	Riverside-San Bernadino, CA

[23] These indices are relative to Abilene, TX

Table 8. Bottom 20 Cities According to the Quality of Life Indices[24]

Rank	Specification 1 (Base Case) (Movers w/ MC)	Specification 2 (Movers w/ MC) Choice Set =40 MSAs
297	Houma-Thibodoux, LA	Houma-Thibodoux, LA
296	Laredo, TX	Laredo, TX
295	Kokomo, IN	Sioux Falls, SD
294	Altoona, PA	Kokomo, IN
293	Sioux Falls, SD	Altoona, PA
292	Mansfield, OH	Mansfield, OH
291	Wausau, WI	Sioux City, IA/NE
290	Gadsden, AL	Wausau, WI
289	Sioux City, IA/NE	Alexandria, LA
288	Alexandria, LA	Gadsden, AL
287	Flint, MI	Flint, MI
286	Wichita Falls, TX	Billings, MT
285	Danville, VA	Springfield, IL
284	St. Joseph, MO	St. Joseph, MO
283	Springfield, IL	Danville, VA
282	Billings, MT	Williamsport, PA
281	Williamsport, PA	Wichita Falls, TX
280	Jamestown-Dunkirk, NY	Sumter, SC
279	Decatur, IL	Jamestown-Dunkirk, NY
278	Sheboygan, WI	Yuba City, CA

[24] These indices are relative to Abilene, TX

Table 9. Second Stage Results

Using Estimates from Specification 1 (Number of Observations =286)	With Census Regions Model 1		With Census Divisions Model 2	
	Coefficient	t-statistic	Coefficient	t-statistic
INTERCEPT	0.4362	0.06	-3.5680	-0.46
MEAN PM10	0.0191	2.21	0.0226	2.60
TOTAL CRIME RATE	-5.1297	-1.79	-5.6049	-1.97
POP DENSITY PER SQ MILE OF LAND	0.0001	3.97	0.0001	4.00
TRANSPORTATION	0.0032	1.75	0.0032	1.79
EDUCATION	0.0062	3.43	0.0064	3.53
ARTS	0.0104	5.58	0.0096	5.18
HEALTHCARE	-0.0005	-0.31	0.0007	0.50
RECREATION	0.0136	7.03	0.0131	6.78
MSA ON THE COAST	-0.1713	-1.97	-0.1772	-2.05
WINTER TEMP AVG	0.1054	3.54	0.0802	2.57
WINTER TEMP AVG SQUARED	-0.0010	-2.78	-0.0007	-1.82
SUMMER TEMP AVG	-0.0692	-0.34	0.0627	0.29
SUMMER TEMP AVG SQUARED	0.0004	0.29	-0.0004	-0.29
WINTERPR	-0.0503	-1.74	-0.0649	-2.06
WINTERPR SQUARED	0.0011	0.97	0.0023	1.91
SUMMERPR	0.0869	1.58	0.0736	1.19
SUMMERPR SQUARED	-0.0013	-0.59	-0.0016	-0.70
NORTH EAST[25]	0.0180	0.13		
MID WEST	-0.1274	-0.90		
WEST	0.8267	2.96		
MIDDLE ATLANTIC[26]			-0.6400	-1.58
EAST NORTH CENTRAL			-0.6330	-1.52
WEST NORTH CENTRAL			-0.9348	-1.97
SOUTH ATLANTIC			-0.4636	-1.15
EAST SOUTH CENTRAL			-0.8483	-2.07
WEST SOUTH CENTRAL			-0.7470	-1.87
MOUNTAIN			0.2459	0.92
NEW ENGLAND			-0.3280	-0.84
Adjusted R-Squared	**0.7525**		**0.7837**	
R-Squared	**0.7698**		**0.7629**	

[25] The left out category is the SOUTH.
[26] The left out category includes the PACIFIC division

Table 10. Marginal Effects of Climate Variables for Movers

Using Estimates from Specification 1	Model 1 With Census Regions		Model 2 With Census Divisions	
	Coefficient	t-statistic	Coefficient	t-statistic
WINTER TEMPERATURE	0.0304	3.14	0.0291	2.80
SUMMER TEMPERATURE	-0.0110	-0.63	0.0002	0.01
WINTER PRECIPITATION	-0.0296	-2.54	-0.0222	-1.53
SUMMER PRECIPITATION	0.0584	4.18	0.0375	1.90

Table 11. Marginal Effects of Climate Variables Using Variants of other Amenities

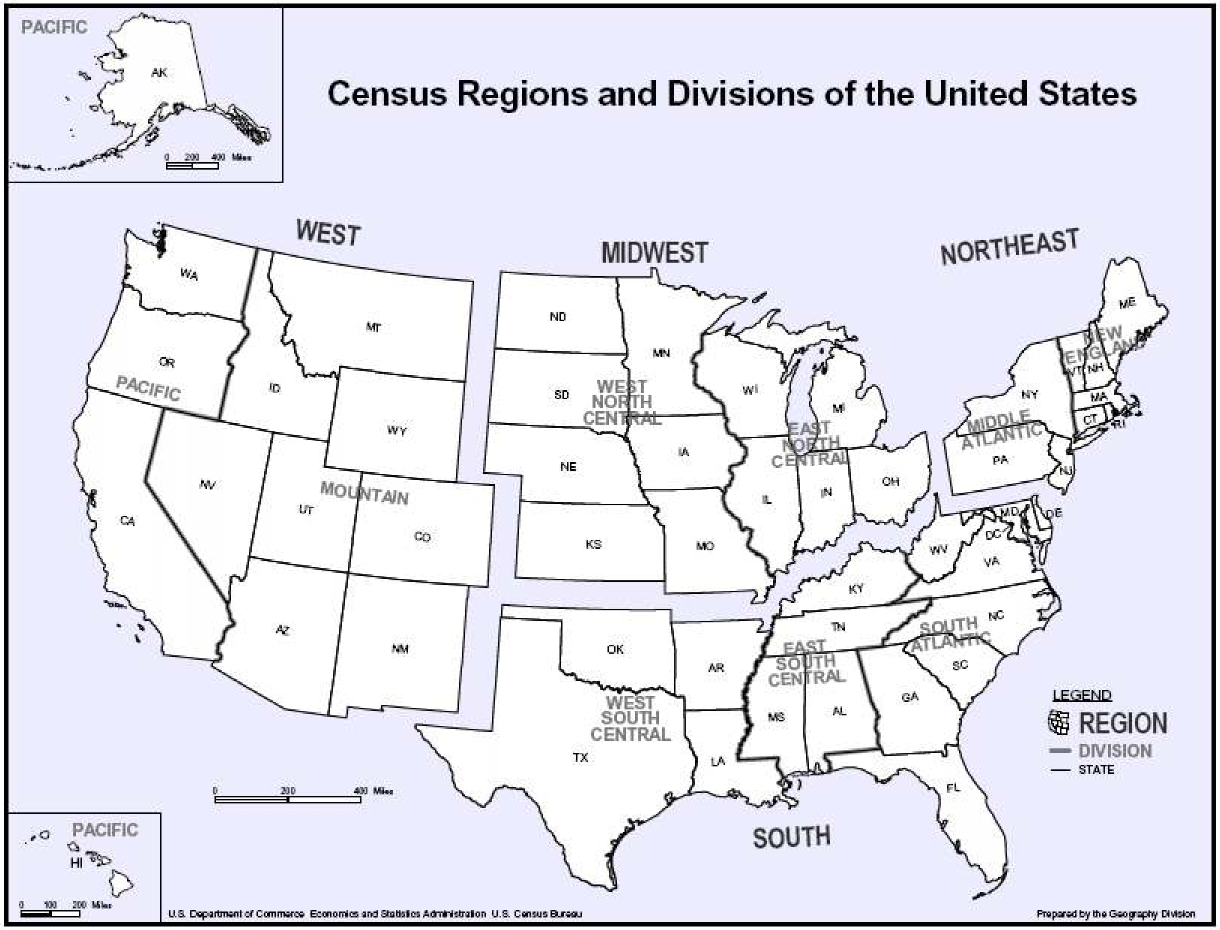
Using PM2.5	With Census Divisions	
	Coefficient	t-statistic
WINTER TEMPERATURE	0.02655	2.54
SUMMER TEMPERATURE	0.01772	0.93
WINTER PRECIPITATION	-0.02469	-1.53
SUMMER PRECIPITATION	0.03529	1.77
Using MSA Out of Attainment with NAAQS	With Census Divisions	
	Coefficient	t-statistic
WINTER TEMPERATURE	0.03098	2.9
SUMMER TEMPERATURE	0.01371	0.75
WINTER PRECIPITATION	-0.01953	-1.34
SUMMER PRECIPITATION	0.03261	1.64
Using Population	With Census Divisions	
	Coefficient	t-statistic
WINTER TEMPERATURE	0.03341	3.53
SUMMER TEMPERATURE	-0.02610	-1.45
WINTER PRECIPITATION	-0.02064	-1.56
SUMMER PRECIPITATION	0.03471	1.93

Using Two Crime Variables	With Census Divisions	
	Coefficient	t-statistic
WINTER TEMPERATURE	0.02913	2.81
SUMMER TEMPERATURE	-0.00148	-0.08
WINTER PRECIPITATION	-0.02151	-1.48
SUMMER PRECIPITATION	0.03623	1.83
Using 3 Coastal Dummies	With Census Divisions	
	Coefficient	t-statistic
WINTER TEMPERATURE	0.03259	2.98
SUMMER TEMPERATURE	-0.00754	-0.37
WINTER PRECIPITATION	-0.02290	-1.58
SUMMER PRECIPITATION	0.03244	1.61

Table 12. Marginal Effects of Climate Variables for Movers Using Different Alpha Values

Using α_H =0.2	Model 1		Model 2	
	With Census Regions		With Census Divisions	
	Coefficient	t-statistic	Coefficient	t-statistic
WINTER TEMPERATURE	0.0299	3.11	0.0286	2.77
SUMMER TEMPERATURE	-0.0100	-0.57	0.0011	0.06
WINTER PRECIPITATION	-0.0294	-2.54	-0.0218	-1.51
SUMMER PRECIPITATION	0.0589	4.24	0.0377	1.93
Using α_H =0.3	Model 1		Model 2	
	With Census Regions		With Census Divisions	
	Coefficient	t-statistic	Coefficient	t-statistic
WINTER TEMPERATURE	0.0310	3.18	0.0296	2.83
SUMMER TEMPERATURE	-0.0121	-0.68	-0.0006	-0.03
WINTER PRECIPITATION	-0.0297	-2.54	-0.0225	-1.54
SUMMER PRECIPITATION	0.0579	4.12	0.0373	1.88

Figure 1. ***(Source[27]: US Census Bureau)***



27 Available online at http://www.census.gov/geo/www/

Figure 2. Marginal Effects of Winter Temperature

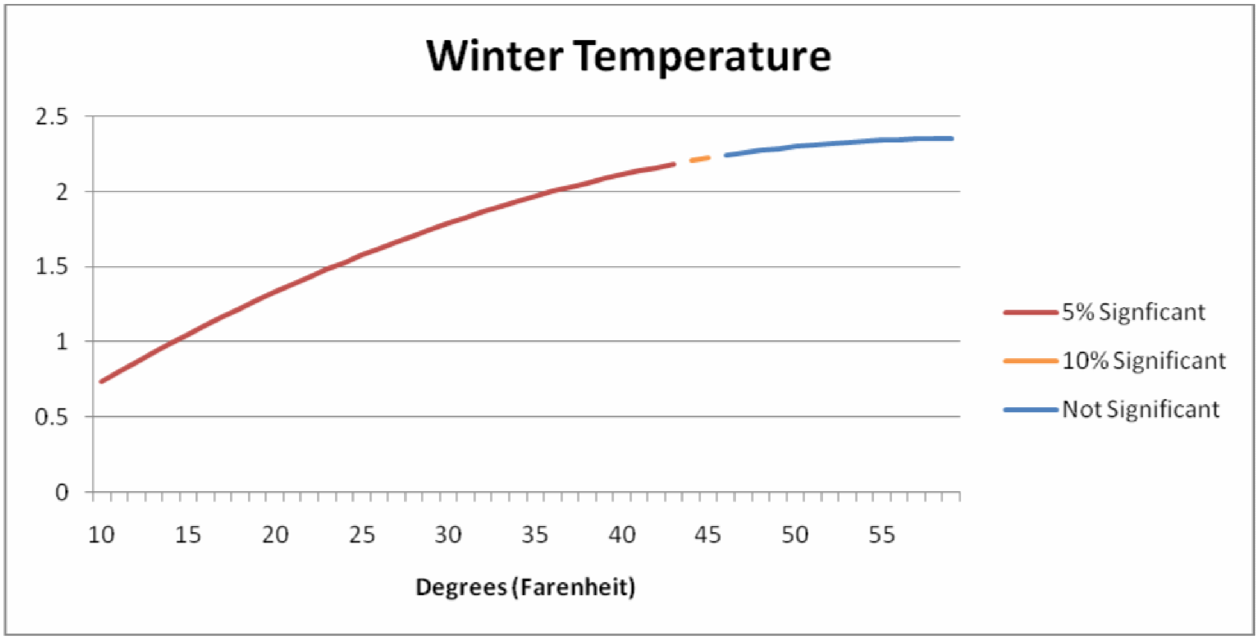


Figure 3. Marginal Effects of Summer Temperature

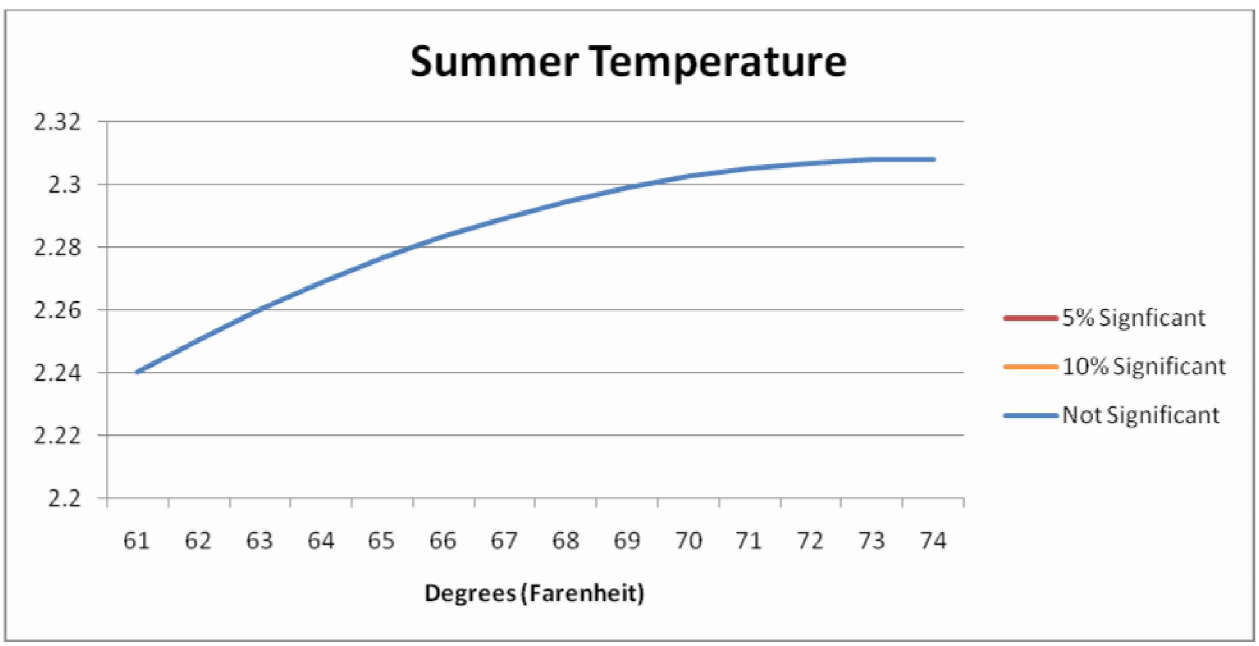


Figure 4. Marginal Effects of Winter Precipitation

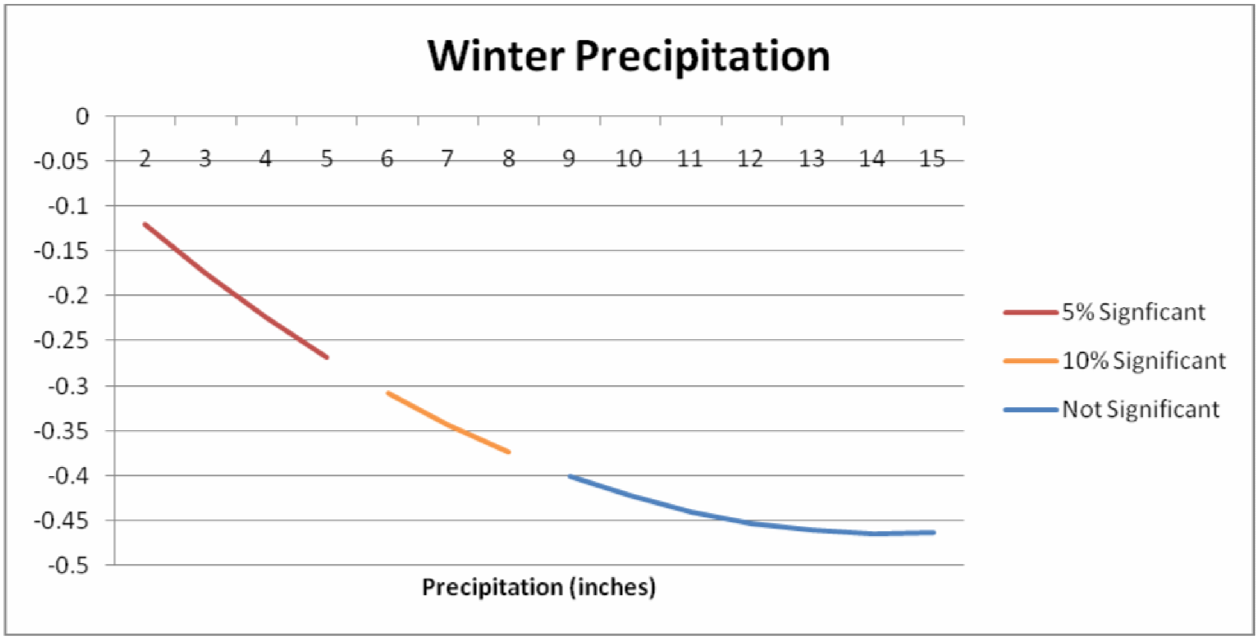


Figure 5. Marginal Effects of Summer Precipitation

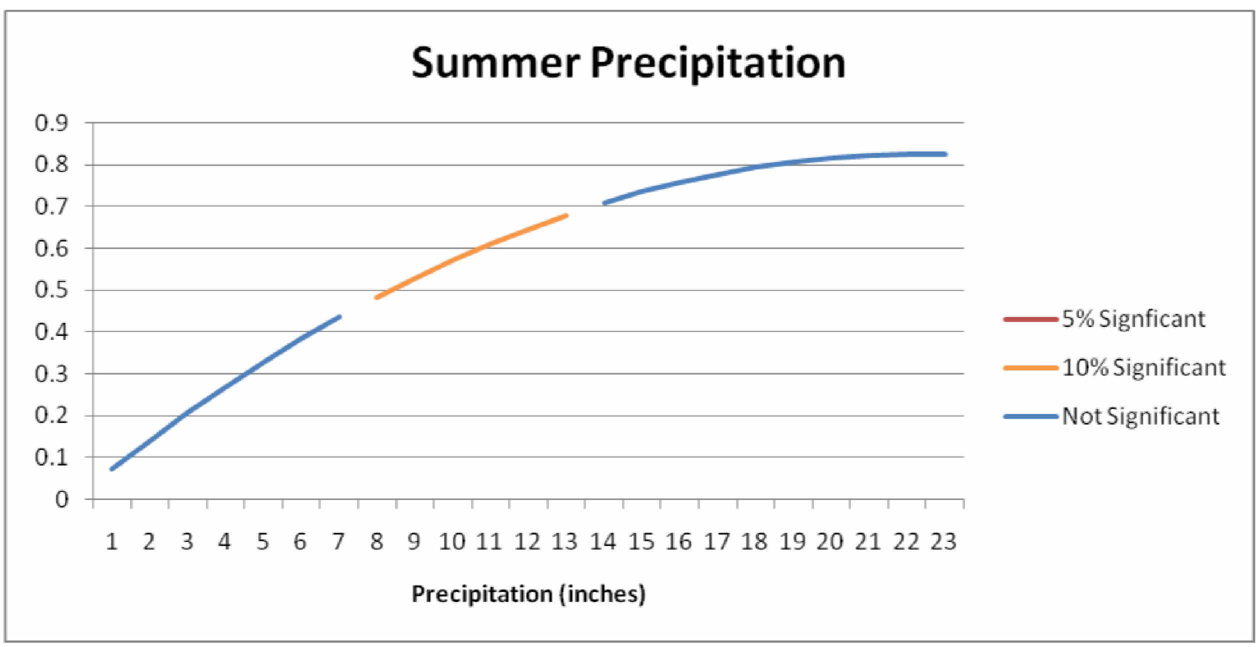


Table A.1 Summary of Hedonic Wage Coefficients

Variables (Dependent Variable: log(wagerate)	Mean of Estimates from 297 MSAs	Std Dev of Estimates from 297 MSAs
Highschool (left out category is no high school)	0.101	0.040
Somecollege	0.181	0.047
Collgrad	0.387	0.070
Highereduc	0.553	0.076
Age	0.051	0.008
Age squared (divided by 100)	-0.049	0.009
Married	0.095	0.022
Male	0.213	0.040
Black (left out category is white)	-0.067	0.075
Other Race	-0.054	0.058
Speaks English Well	0.111	0.117
Hispanic	-0.043	0.080
Business operations_Occ (left out category is Management_Occ)	-0.125	0.067
Financialspecialists_Occ	-0.114	0.078
Computerandmath_Occ	-0.002	0.090
Engineering_Occ	-0.074	0.084
Lifephysicalsocialsc_Occ	-0.183	0.112
Socialservices_Occ	-0.345	0.085
Legal_Occ	-0.040	0.137
Teachers_Occ	-0.200	0.091
Othereduc_Occ	-0.486	0.134
Artssportsmedia_Occ	-0.253	0.098
Healthcarepractitioners_Occ	0.074	0.077
Healthcaresupport_Occ	-0.323	0.081
Protectiveservices_Occ	-0.237	0.106
Foodandserving_Occ	-0.419	0.076
Maintenance_Occ	-0.466	0.079
Personalcareservice_Occ	-0.413	0.112
Highskillsales_Occ	-0.135	0.068
Lowskillsales_Occ	-0.228	0.064

Officesupport_Occ	-0.298	0.052
Constructiontrades_Occ	-0.239	0.094
Extractionworkers_Occ	-0.261	0.292
Maintenanceworkers_Occ	-0.185	0.067
Production_Occ	-0.310	0.085
Transportation_Occ	-0.356	0.074
Construction_Ind (left out category is Mining And Utilities)[28]	-0.178	0.098
Manufacturing_Ind	-0.118	0.108
Wholesale_Ind	-0.185	0.099
Retail_Ind	-0.342	0.098
Transportation_Ind	-0.093	0.110
Informationcomm_Ind	-0.139	0.114
Finance_Ind	-0.173	0.107
Profscientificmngmntservices_Ind	-0.223	0.106
Educhealthsocialservices_Ind	-0.274	0.096
Recreationfoodservices_Ind	-0.378	0.114
Otherservices_Ind	-0.361	0.101
Publicad_Ind	-0.131	0.100

[28] Since these two industries have a very low number of observations, we bundled them together as the left out category.

Table A.2: Coefficients of the Hedonic Housing Equation

Dependent Variable : Log(user costs including insurance and utility costs) Number of Observations Used: 3346588 Adjusted R-Sq: 0.5737		
Variables	**Coefficient**	**t-statistic**
Intercept	5.625	499.41
Own (=1 if the house is owned)	0.505	633.95
Bedroom3 (left out category is less than three bedrooms)	0.129	100.49
Bedroom4	0.154	99.42
Bedroom5	0.284	162.02
Bedroomgt5	0.486	225.45
Room2 (left out category is less than two rooms)	0.139	69.27
Room3	0.140	73.67
Room4	0.169	79.76
Room5	0.233	103.99
Room6	0.329	141.05
Roomgt6	0.533	224.08
Completekitchen	-0.035	-9.65
Completeplumbing	0.218	55.93
Acres1to10	-0.214	-97.46
Ageofstructure_0to1years (left out category is age of structure over 61 years)	0.390	192.86
Ageofstructure_2to5years	0.369	292.34
Ageofstructure_6to10years	0.314	255.44
Ageofstructure_11to20years	0.216	216.27
Ageofstructure_21to30years	0.108	113.21
Ageofstructure_31to40years	0.058	59.24
Ageofstructure_41to50years	0.020	20.83
Ageofstructure_51to60years	-0.025	-22.00
Unitsinstructure _Singleattached (left out category is units in structure single family detached)	-0.157	-139.84

Units_In_Structure _2	-0.270	-106.24
Units_In_Structure _3to4	-0.326	-127.97
Units_In_Structure _5to9	-0.353	-137.60
Units_In_Structure _10to19	-0.330	-125.94
Units_In_Structure _20to49	-0.382	-142.59
Units_In_Structure _Over50	-0.367	-143.29