(2012) 42, 223–248

The Review of Regional Studies

The Official Journal of the Southern Regional Science Association

Does Urban Density Promote Social Interaction? Evidence from Instrumental Variable Estimation*

Zackary B. Hawley

Department of Economics, Texas Christian University, USA

Abstract: To test the common assumption that increased local area population density implies high levels of social interaction, I use instrumental variable estimation to examine a causal link between social interaction and urban population density. I instrument for local population density using earthquake and landslide hazard rates in addition to the presence of hard rock beneath the soil. I find the social interaction type matters when determining the relationship with population density. Social interaction with friends is positively related with population density, whereas neighbor interaction is negatively related. Group involvement does not seem to be systematically related to population density.

Keywords: social interaction, instrumental variables, population density

JEL Codes: R0, C36

1. INTRODUCTION

Of the estimated 315 million people in the United States, 85 percent live in urban areas.[1] This agglomeration of population in US cities leads to many advantages, as economists have documented.[2] The economic benefits of cities are the foundation of such high population densities, particularly when the supply of land is not a binding constraint. The interest in the social environment of cities, while certainly not a new topic, is maturing for urban economists as data on social attitudes and social immersions are increasingly becoming available. The social structure, described with many terms such as *social interaction*, *social involvement*, or *social capital*, can influence a variety of economic outcomes. The question becomes how the urban built environment and the consequent population density combine to affect various forms of social interaction within cities. Interestingly, authors of theoretical models often assume that social interaction increases with population density.[3] There is little to no empirical analysis that clearly supports this assumption, however.

*I thank Michael Lahr and three anonymous referees for their comments. I also thank Andrew Hanson, Jon Rork, Charles Sawyer, and Geoffrey Turnbull for helpful guidance, discussion, and comments. I thank participants at the Georgia State University economics department seminar and the Western Economic Association Annual Meeting for insightful comments and discussion. I also thank Dave Sjoquist and acknowledge funding for this research from the Dan E. Sweat Dissertation Fellowship.

Hawley is Assistant Professor in the Department of Economics at Texas Christian University, Fort Worth, Texas, USA. E-mail: z.hawley@tcu.edu

[1] Estimates of total population and urban population (July 1, 2012) are from the Census Bureau. Urban areas imply all metropolitan divisions.

[2] Rosenthal and Strange (2004) provide a detailed reference list on agglomeration economies.

[3] Social interaction is defined as a good in this context. Social interaction in a broader sense may include some negative effects such as crime. This type of social interaction is not evaluated in this paper.

ISSN 1553-0892, 0048-749X (online)

www.srsa.org/rrs

I test whether increased local population density causes increased social interaction. This paper adds to the literature by evaluating a common assumption that increased density leads to higher levels of interaction.[4] Brueckner and Largey (2008) provide one alternative empirical test of this relationship. The authors show theoretically how a density externality can lead to social interaction that causes urban sprawl. The crucial assumption in their theoretical model is that social interaction increases with population density. The authors' empirical test of this assumption does not support the statistical relationship of social interaction to local population density. This result is not consistent with what urban economists expect or readily include in models of social activities. I use a more refined set of instruments to reexamine the connection between social interaction and population density, and, in contrast with the previous findings, I find empirical support for the link between social interaction and local population density.

Using data from the Social Capital Community Benchmark Survey (SCCBS), which provides information on social interaction, I estimate the relationship between local population density and social interaction. Since population density and social interaction arise simultaneously, researchers have difficulty determining the causal direction of their relationship. To solve this endogeneity issue, I instrument for local population density using earthquake and landslide hazard rates in addition to the presence of hard rock beneath the soil. The identification strategy assesses the validity of the assumption that social interaction and local population density are positively related.

I find social interaction strictly increases with population density only for particular types of social interaction. Social interaction involving friends increases with population density, but neighbor and group social interaction declines with increased density. Additionally, I find mixed relationships between index measures of social interaction, such as social trust, faith biased, civic participation, or diversity, and population density.

The remainder of the paper continues as follows. Section 2 provides a brief literature review. Section 3 states the identification strategy for the empirical methods. Section 4 discusses the data used. Section 5 presents the empirical findings. The final section presents the study's conclusions.

2. LITERATURE REVIEW

For many decades, social science has studied the social environment arising from people congregating tightly in space. Sociologists have analyzed two competing effects of higher population density: productivity (Durkheim, 1933) and stress (Simmel, 1964), which emerge from higher levels social interaction. These classical views of high population density "argue that the level of population density in a human society has important social consequences" (Winsborough, 1965, p. 121), but whether these consequences are positive or negative is still debatable.

Urban planners have also recognized the importance of social interactions and a contending need for privacy to maintain the vibrancy and sustainability of urban areas. The balance between the two is critical for healthy urban environments. As Jacobs (1961, p. 56) says, "Cities are full of people with whom…a certain degree of contact is useful or enjoyable; but you

[4] The effects of increased social interaction on economic outcomes are outside the scope of this paper. While certainly important, the underlying connection which precedes most of the changes in outcomes arises due to the assumption of increased interaction with density.

do not want them in your hair". While in jest, Jacobs brings up an important point about the duality of social contact. While I grant that not all social interaction yields gains in happiness,[5] this paper focuses on social interaction as a good.

Economists describe various social aspects of cities, such as peer effects,[6] neighborhood effects,[7] and social capital, all of which lack a solid economic definition (Manski, 2000). I define social interaction as nonmarket originating, reoccurring, yet unique face-to-face interaction,[8] where both parties are interested in a response. Economists have examined the effects of social interaction intensity on various outcomes. For example, health economists have shown that social interactions affect health outcomes such as smoking and weight.[9] In finance, the sociability of members of a household, including interacting with neighbors or an affiliation with a religious institution, positively influences their choice to engage in financial markets (Hong, Kubik, and Stein, 2004). Hogler, Shulman, and Weiler (2004) discuss the role of social capital on state level union density and the effects on labor markets. Education achievement is also related to the social support of interpersonal interaction of students with family, community, and school. (Israel and Beaulieu, 2004)

In urban economics, researchers see social interaction as a pillar for the existence of cities. Glaeser and Gottlieb (2006, p. 1275) state that "cities make it easier to interact, and one of the main advantages of dense, urban areas is that they facilitate social interactions." There is also a growing literature on the effect of social interaction on the shape of cities. Gasper and Glaeser (1998) suggest cities will no longer exist if technological advancements remove the need for face-to-face interaction, but they find cities will continue to exist, since face-to-face interaction and technological advancements are not strong substitutes. More recently, urban economists began to analyze the importance of the spatial structure for social interaction to occur and how it affects network formation for the urban area as a whole (Helsley and Zenou, 2011). Hilber (2010) provides additional evidence that homeowners invest more into human capital through social interaction, especially in areas with a more inelastic housing supply. Further, Abel, Dey, and Gabe (2012) test productivity gains resulting from enhanced interaction within urban areas.

Along with the sociologists and urban planners, urban economists recognize the important influence of urban population density on social interaction. A commonality in the literature is the assumption that social interaction increases with population density.[10] The logic is straightforward—with denser population, individuals will interact more often. Many forms of this assumption appear in theoretical or empirical research. Interestingly, even with all the effort

[5] Detrimental effects may be due to negative marginal utility along some range of interaction levels or population density; I will test for these effects. But also, social interaction could suffer negative absolute utility, in examples like bullying or a preference for solitude.

[6] Economists generally attribute peer effects to changes in behavior due to exposure to other ideas put forth by co-workers, friends, fellow students, etc. Social interactions may be the channel by which peer effects occur but the measurement of these two ideas is different. See Bayer, Hjalmarsson, and Pozen (2009) for a review of peer effects.

[7] I argue that there is a distinct difference between social interaction and neighborhood effects—neighborhood effects are exogenous after location is chosen, where social interaction is still endogenously determined even after location is chosen.

[8] I recognize all social interaction need not be face-to-face. Ellison, Steinfield, and Lampe (2007) examine the link between computerized social interaction and social capital levels.

[9] Jones (1994) and Trogdon et al. (2008) are just two of many examples.

[10] For example, Abel, Dey, and Gabe (2010, p. 567) state: "density can enhance labor productivity by increasing the frequency of physical interactions and face-to-face contact" The assumption of increasing interaction with density is also embedded in their theoretical model.

aimed at social interaction, the literature is not empirically clear on how population density does affect social interaction. Additional density may provide more opportunities for contact (or even better contact), or perhaps, as population density climbs, overcrowding leads to lower levels of social interaction.

The goal of this paper is not to determine the various economic outcomes affected by social interaction, but to support the link between local population density and these nonmarket interactions. While determining economic effects is outside the scope of this paper, these interactions can lead to significant economic impacts, and some of the results presented here may provide additional evidence in support of these effects.[11]

3. IDENTIFICATION STRATEGY

I use an instrumental variables empirical method to test the relationship between social interaction and local population density. The demand for social interaction will likely determine an individual's choice of density. It is not obvious if the individual chooses a level of social interaction in response to the density surrounding her, or the individual selects a density that matches the social interaction desired. This ambiguity is the classic simultaneity problem. Thus, I use instrumental variable estimation to obtain consistent estimates of local population density's effect on social interaction.

The set of instruments includes a measure of seismic hazard, landslide hazard, and the presence of sedimentary rock under the soil.[12] The seismic hazard instrument measures how potentially strong and likely seismic activity is for a location. More precisely, the instrument measures the maximal horizontal acceleration of the earth as a multiple (or percentage) of gravity along with the potential severity of an earthquake; there is correlation between potential severity and probability of occurrence. This instrument affects population density through additional cost in building structures that take into account seismic activity. The variable's range is from 0 to 100, and it does not correspond directly with census tracts. Thus, the census tract measure is the area weighted average of the scores located inside the tract.

One complication with the seismic hazard instrument is that all of the high (30 or over) scores are located on the west coast. I create two additional instrumental variables using the seismic hazard rate: a tract level dummy variable indicating a high value for the hazard rate,[13] and an interaction with the dummy variable and the original seismic variable. The creation of these two additional variables avoids the seismic hazard rate being confounded with a regional effect and allows the trend for building along the west coast to vary from the overall effect on building as the hazard increases.

The landslide hazard measure takes values of low, medium, and high (1, 2, and 3, respectively) and represents how likely a landslide is to occur. The rationale supporting this instrument is if the area is prone to landslides, the inhabitants are less likely to build upon that land for fear of losing their homes. I calculate the landslide hazard instrument at the census tract level as an area weighted average of its values.

---

[11] Granovetter (2005) provides a great discussion of how social interaction can lead to and affect economic outcomes.

[12] Rosenthal and Strange (2008) use a similar set of instruments to obtain consistent estimates of the effect density has on labor market outcomes.

[13] The dummy equals unity if the area weighted seismic hazard score is above or equal to 30, zero otherwise.

The last geological instrument is the percentage of area within a census tract in which sedimentary bedrock occurs. The type of rock found deep in the earth is important for determining the type of structure placed on top of the ground. The harder the rock, the higher and larger the structure's potential. Since high density areas need large and tall structures to house masses of people, the type of rock can determine the feasibility or ease of such housing.

The instrumental variable technique relies on the instruments themselves, not directly influencing the level of social interaction except through their effect on population density. The instruments are naturally occurring and it is difficult to link social interaction with them except through their effect on density. Further, the instruments have both inter and intra urban area variation. If the level of social interaction in an urban area depends upon its natural structure, then the inter-area variation within the instruments confounds the estimated relationship. The instruments, however, describe intra-area variation and account for local density differences within the urban area. The instrument exogeneity and intra-area variation provide advancement to the literature as previous empirical work lacked instruments with these characteristics.

I consistently test the relationship between social interaction and local population density using an instrumental variables approach. In the first stage, I instrument for density,

$$\textit{Tract Density}_i = \alpha + \boldsymbol{\beta}\mathbf{y}_i + \boldsymbol{\delta}\mathbf{x}_i + \varepsilon_i \quad (1)$$

where the natural logarithm of tract population density is the dependent variable and **y** is the set of geological instruments. The coefficients of interest in the first stage are represented by the vector **β**, or the effect of the instruments on tract density. I expect to find a negative relationship with density for the seismic hazard, the seismic interaction and the landslide hazard and a positive relationship for the high seismic indicator and the sedimentary rock instrument.

A vector of other control variables, **x**, includes socioeconomic variables such as age, income, marital status, children, race, and others.[14] I include regional dummies in the specification within **x**.

In the second stage of the estimation, I test the assumed positive link between social interaction and density.[15]

$$SocInter_i = \alpha_1 + \beta_1 \widehat{TractDensity}_i + \boldsymbol{\delta}_1 \boldsymbol{x}_i + \varepsilon_i \quad (2)$$

Again I include the control variables, **x**, in the full specifications. The dependent variables are friends, neighbor, group involvement, and index measures of social interaction which I describe below.

4. DATA

4.1 Social Interaction Data

I use data from the Social Capital Community Benchmark Survey (SCCBS). The Roper Center for Public Opinion Research at the University of Connecticut distributes the survey,

[14] The full list of additional controls is as follows: gender, age, age squared, marital status, number of children, income, education, race, ethnicity, employment, citizenship, tenure in neighborhood, MSA murder rate, MSA dissimilarity index, and census region dummy variables.
[15] I also test the second-order effects of population density on social interaction, but use a level-level specification and report only the direction of this effect, as marginal inference adds little to the explanation.

which took place in 2000.[16] The Saguaro Seminar at the John F. Kennedy School of Government, Harvard University, designed the survey with the intention of formulating a uniform measure of social capital.

These data include a national sample as well as 41 separate "community" samples. The national sample includes just over 3000 respondents, chosen at random across the Continental U.S. with over-sampling of African Americans and Hispanics.[17] As for the 41 "communities," the survey defines each separate community differently across space; some "communities" capture a single city, while others encompass entire states.[18] Different institutions or individuals sponsored each of the community samples, so the sampling techniques are not uniform across the communities.[19] The total number of observations in the data set is just under 30,000.

The restricted use SCCBS identified individual locations by the census tract. As I concentrate on individuals who reside within an urban area, a respondent is in the sample if the tract in which she resides intersects at any point with an urbanized area. The data include about 21,500 observations varying slightly for each social interaction measure due to missing values.[20] The observations are located within over 300 separate urbanized areas.

The SCCBS conducted phone interviews with respondents to ask about their experiences related to trust, friendship and social activities in their communities. I focus on the questions that address social information or non-market exchange. These select questions measure how interactive the respondents are within their respective community. The ten social interaction dependent variables comprise two categories, friendship and group involvement.

I use six different measures of friendship. First, how often the respondent socializes with his neighbors (*NEISOC*). Second, whether the respondent talks with a neighbor more than once a week (*NEITALK*). Third, in how many people can the respondent confide (*CONFIDE*). Fourth, how many "close" friends the respondent has (*FRIENDS*). Fifth, how often the respondent "hangs out" in public places with friends (*SOCPUBLIC*). Last, how often friends visit the respondent's home (*SOCHOME*).

Four variables capture group involvement. First, the respondent's participation in a neighborhood cooperation (*NEICOOP*); second, whether the respondent participates in a hobby-oriented club (*GRPHOB*); third, how often the respondent went to any club meeting (*CCLUBMET*); last, the number of non-church groups in which the respondent is involved (*GRPINVLV*).

Additionally, the survey includes several index variables. These indices include information provided by the respondents found in the survey, not necessarily containing the social interaction measures above. I use four indices: social trust (*SOCTRUST*), faith-based

[16] Access to the unrestricted data can be found through www.roper.uconn.edu.

[17] African Americans and Hispanics account for 500 respondents each which resulted in an additional 288 African Americans and 294 Hispanics in the sample than otherwise would have been under random sampling.

[18] As an example, Atlanta is defined as a community which includes counties that are in the MSA whereas Indiana is defined as a community which includes respondents selected random across the entire state.

[19] There are several different sampling techniques used across the communities. One community may sample heavier in Hispanics while another oversamples Native Americans. The sponsor of the community sample may have been interested in a particular group of people and required more information from that group.

[20] There is one exception, *NEICOOP*, or working together with neighbors to get something fixed or improved, which is missing a significant amount of responses.

interaction (*FAITHBAS*), civic participation (*CIVICPART*), and friendship diversity (*DIVERSITY*).

The social trust index attempts to capture the broad notion of trust in others. General interpersonal trust, trusting neighbors, trusting police, and trusting others are included in this index. This index may be the furthest from social interaction as I defined it, but trust is pivotal in the determination of interaction. The respondent who does not trust his neighbors is probably much less prone to interact with them. Faith-based interaction includes church membership and attending church service. The civic participation index compiles various interactions dealing with local politics and community activities—attending a political meeting or rally, working on a community project, and demonstrating, protesting, boycotting, or marching. This index is most in line with the types of individual forms of social interaction used in this paper. Further, Briggs (2008) discusses how this type of civic capacity is central for communities dealing with important problems. Friendship diversity measures how many different types of people a respondent considers friends. The types of friends include several categories based on race, ethnicity, employment status, being a community leader, etc.

4.2 Instrument Data

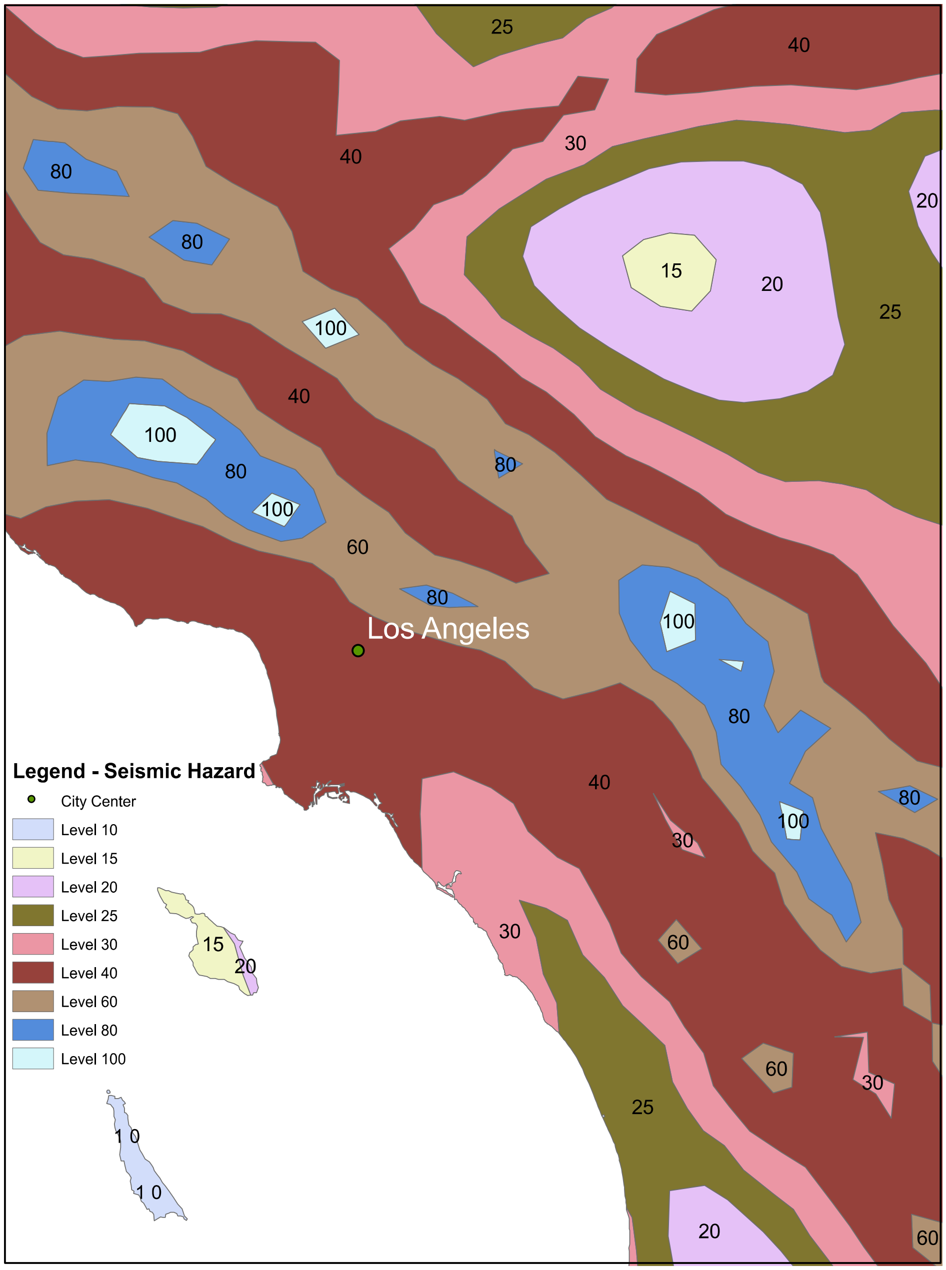
The instrument data come from the United States Geological Survey (USGS). The USGS readily supplies the information through its website as boundary files which are downloadable in shape-file format. I overlay these data with census tract boundary shapefiles to calculate the area-weighted scores for each instrumental variable at the tract level. Figures 1-3 show examples of each instrument map. Figure 1 shows a seismic hazard map of Los Angeles, California. This map demonstrates the variation in the seismic hazard instrument (the range is from 0 to 100). The seismic gradients do not follow exactly the census tract boundaries, so I create an area-weighted average of the seismic score for each census tract which constitute the seismic hazard instrument. The values of the instrument measure take the same range as the seismic hazard rate. The instrument, however, is not an integer scale.

Figure 2 presents a landslide hazard map of Atlanta, Georgia. In this map, the landslide hazard displays its full range. The landslide hazard instrument constructed is the area-weighted average of the values. Again, the range for the landslide hazard instrument is identical to the landslide hazard (1 to 3), but the instrument is no longer in integer form.

Figure 3 displays a sedimentary rock map for Boston, Massachusetts. As shown, the presence of sedimentary rock does not coincide with the drawing of census tracts. The construction of the instruments is enhanced in this map. Each census tract embraces two categories—sedimentary rock and non-sedimentary rock. I calculate the area of each and compute the ratio to the total census tract area. The range of values for the sedimentary rock instrument is from 0 to 1, with non-integer values possible.

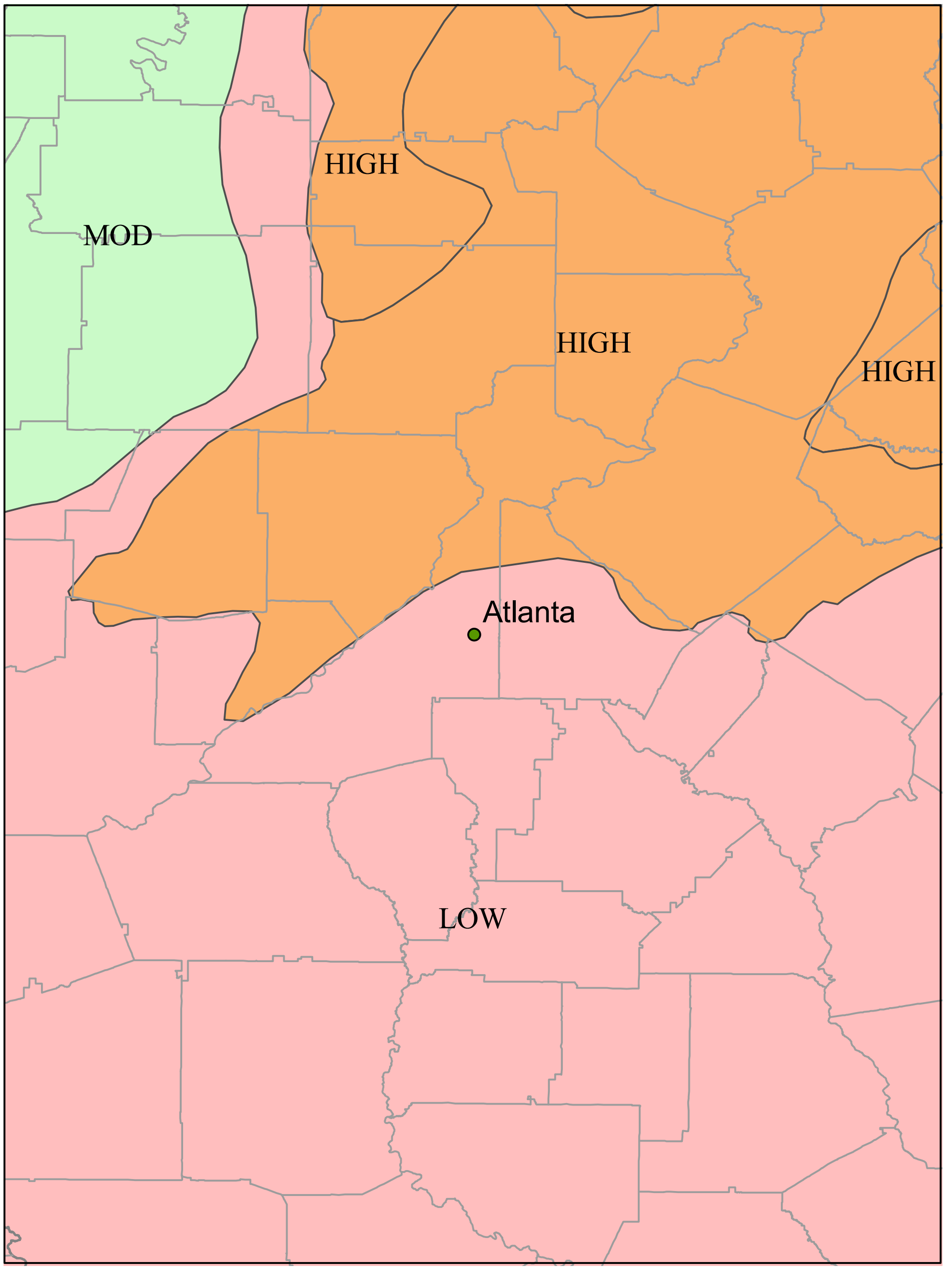
Table 1 provides a description of the full set of variables. The variables of interest are the social interaction terms described above as well as the population density of each tract, in natural log form. The social interaction measures are categorical or binary responses, complicating the intuition for the magnitudes. For example, the average level of socializing at home is 21.95, which corresponds to around twice a month. Alternatively, almost 54 percent of the individuals in the sample talks with or visits immediate neighbors at least once a week.

Figure 1: Seismic Hazard Rate – A Map of Los Angeles, CA



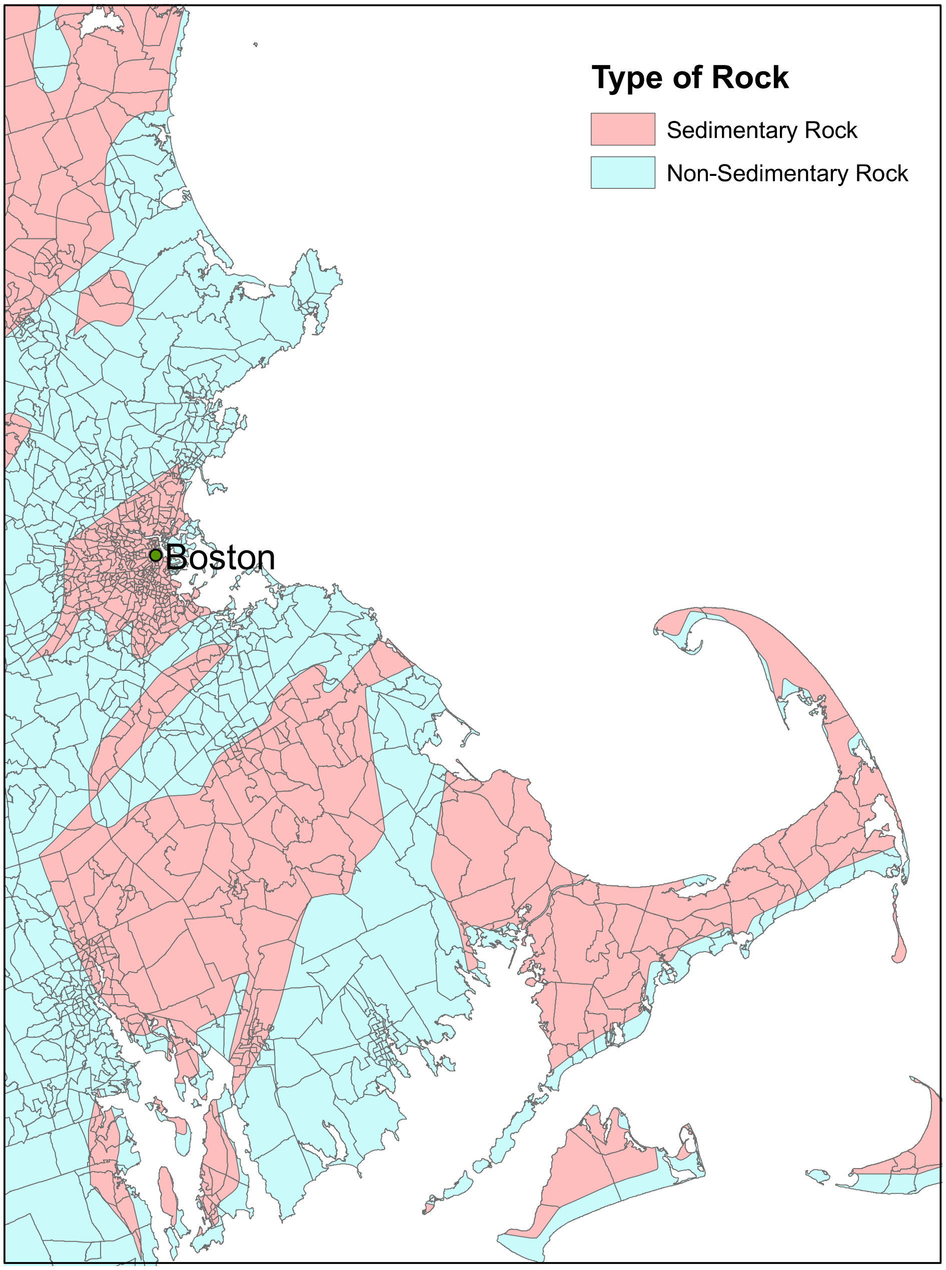
Source: United States Geological Survey. Map shows seismic hazard rates around Los Angeles, CA

Figure 2: Landslide Hazard Rate – A Map of Atlanta, GA



Source: United States Geological Survey. Map shows various landslide hazard rates around Atlanta, GA.

Figure 3: Sedimentary Rock Instrument – A Map of Boston, MA



Source: Untied States Geological Survey. Map shows the different types of rock beneath the soil around Boston, MA.

Table 1: Summary Statistics and Variable Definitions

Variable	Definition	Mean	Std. Dev.	Min	Max
Social Interaction Variables					
#NEITALK	How often respondent talks with or visits immediate neighbors: 1 = never, 2 = once a year or less, 3 = several times a year, 4 = once a month, 5 = several times a month, 6=several times a week, 7=just about every day	5.061	1.848	1	7
NEITALK	=1 if respondent talks or visits immediate neighbors at least once a week, 0 otherwise	0.539	0.498	0	1
CONFIDE	Number of people respondent can confide in: 1=nobody, 2=one, 3=two, 4=three or more	3.550	0.787	1	4
FRIENDS	Number of close friends respondent has: 1=none, 2=one or two, 3=three to five, 4=six to ten, 5=more than ten	3.317	1.063	1	5
SOCPUBLIC	Number of times per year respondent hangs out with friends in a public place	16.968	20.147	0	60
SOCHOME	Number of times per year respondent visits with friends at home	21.975	21.214	0	60
NEICOOP	=1 if respondent has worked with neighbors to get something fixed or improved	0.318	0.466	0	1
HOBBYCLUB	=1 if respondent participates in a hobby, investment or garden club	0.262	0.440	0	1
CLUBMTGS	Number of times per year respondent attends club meetings	6.195	12.163	0	60
#GROUPS	Number of types of non-religious organizations to which respondent belongs	3.041	2.620	0	17
Social Interaction Indices					
FACTOR	Factor analysis of the ten social interactions above.	0	0.890	-1.699	1.04
FACTOR2	Factor analysis of nine social interactions, leaving out NEICOOP due to missing values.	0	0.888	-1.629	0.967
SOCTRUST	Index of social trust.	-0.011	0.697	-2.631	1.015
FAITHBAS	Index of faith-based interactions.	-0.087	0.770	-1.110	1.663
CIVICPART	Index of political and community involvement.	1.763	1.276	0	5

DIVERSITY	Index of diversity in friendships.	6.378	2.669	0	11
Population Density Measure					
TRACT DENSITY	Natural log of census tract density: people per square mile	8.029	1.343	0.869	12.286
Instruments for Density					
SEISMIC HAZARD	Hazard rate of seismic activity in potential and magnitude.	11.610	19.372	0	90.6
HIGH SEISMIC	=1 if seismic hazard rate is 30 or above.	0.165	0.371	0	1
SEISMIC INTER.	Interaction term of high seismic and seismic hazard.	8.672	20.304	0	90.6
LANDSLIDE	Hazard rate of landslide activity.	1.573	0.693	1	3
SED. ROCK	Percentage of sedimentary rock found below the earth's surface.	0.833	0.359	0	1
Respondent Characteristics					
MALE	=1 if respondent is male, 0 otherwise	0.414	0.493	0	1
AGE	Respondent’s age in years	44.042	16.592	18	99
AGE2	AGE squared				
MARRD/PARTN	=1 if respondent is married or living with partner, 0 otherwise	0.564	0.496	0	1
KIDS6	Number of children in household under six years old	0.266	0.685	0	8
KIDS6_17	Number of children in household between six and seventeen	0.489	0.920	0	8
INC2	=1 if $20k < annual household income < $30k	0.123	0.328	0	1
INC3	=1 if $30k < annual household income < $50k	0.217	0.412	0	1
INC4	=1 if $50k < annual household income < $75k	0.173	0.378	0	1
INC5	=1 if $75k < annual household income < $100k	0.102	0.302	0	1
INC6	=1 if annual household income > $100k	0.117	0.322	0	1
SOMECOLL	=1 if respondent has completed some college education, 0 otherwise	0.323	0.468	0	1
COLLGRAD	=1 if respondent has a college degree, 0 otherwise	0.374	0.484	0	1
BLACK	=1 if respondent is black, 0 otherwise	0.150	0.357	0	1
HISPANIC	=1 if respondent is Hispanic, 0 otherwise	0.092	0.288	0	1
ASIAN	=1 if respondent is Asian, 0 otherwise	0.031	0.173	0	1

UNEMP	=1 if respondent is unemployed, 0 otherwise	0.026	0.160	0	1
HOMEMAKER	=1 if respondent is a home-maker, 0 otherwise	0.062	0.241	0	1
RETIRED	=1 if respondent is retired, 0 otherwise	0.149	0.356	0	1
CITIZEN	=1 if respondent is a US citizen, 0 otherwise	0.935	0.246	0	1
LIVING5	=1 if respondent has lived in his/her community for more than five years, 0 otherwise	0.649	0.477	0	1
Regional Controls. Omitted Category: Pacific					
NEWENGL	=1 if census region is New England, 0 otherwise	0.043	0.204	0	1
MIDATLAN	=1 if census region is Mid Atlantic, 0 otherwise	0.086	0.282	0	1
EANOCENT	=1 if census region is East North Central, 0 otherwise	0.220	0.414	0	1
WENOCENT	=1 if census region is West North Central, 0 otherwise	0.067	0.250	0	1
SOUTHATL	=1 if census region is South Atlantic, 0 otherwise	0.213	0.410	0	1
EASOCENT	=1 if census region is East South Central, 0 otherwise	0.041	0.198	0	1
WESOCENT	=1 if census region is West South Central, 0 otherwise	0.053	0.223	0	1
MOUNTAIN	=1 if census region is Mountain, 0 otherwise	0.069	0.254	0	1
Urban Area Controls					
MURDER	Number of murders per 100,000 people within Urban Area	6.123	4.017	0	20.4
DISSIMILARITY	Dissimilarity index for segregation of blacks versus non-blacks	0.566	0.141	0.211	0.840

The descriptive table shows respondents in the sample are 41 percent male, 56 percent married, 37 percent college graduates, 15 percent African American, 15 percent retired, and on average 44 years of age. The average seismic hazard rate for the sample is just over a score of 11. Respondents reside in a high seismic hazard area (score of 30 or above) in about 16 percent of the sample. The average landslide hazard rate is 1.5, and the average tract in the sample has 83 percent of its area with sedimentary bedrock beneath the soil. The additional controls include some data from other sources. The MSA level murder rate comes from the Federal Bureau of Investigation's Uniform Crime Reports. The dissimilarity index captures how racially segregated the population is within a MSA, which comes from Cutler, Glaeser, and Vigdor's data website.[21]

[21]The dissimilarity index was found at http://trinity.aas.duke.edu/~jvigdor/segregation/index.html.

5. RESULTS

For each of the social interaction measures, I estimate two different specifications. The base model is a bare-bones approach that only utilizes the instruments in the first stage and then tests the relationship between social interaction and tract density with no other controls included. The full model incorporates the control variables, $\mathbf{X}_i$, in the first and second stages. In both models, I use clustered standard errors at the urbanized area.

5.1 First Stage Results

Table 2 shows the first stage results for the geological instruments. For each of the instruments, the first stage results largely yield the expected relationship with tract density and are highly significant. The landslide hazard instrument yields the expected negative relationship in the base model, but in the full model, the relationship is not significantly different from zero. The seismic hazard instruments, comprised of the rate, dummy, and interaction variables mostly follow intuition. In the base model, the relationship between tract population density and the rate of seismic hazard is positive, when I control for a significantly positive West Coast effect with the dummy for high hazard values. The interaction term is negative, signifying that as the hazard increases in a high hazard environment, tract population density declines. In the full model, the results are more precise. The hazard rate is now significantly positively related to density, and the interaction coefficient is significantly negative. The relationship of sedimentary rock to density is positive in both specifications but statistically insignificant in the full model.

I use a number of tests to estimate the strength of the instruments. In every specification, the first stage *F*-statistic is well above 10, the rule of thumb for instrument relevance in the first stage. I conduct various tests of the instruments. Under-identification does not seem to be a concern, nor does weak identification as the Kleibergen-Paap tests reject the null in both cases. Additionally, the Anderson-Rubin test shows the instruments strongly predict local population density.

5.2 Friends and Neighbors Results

Table 3 presents the relationship between census tract population density and social interactions involving friends and neighbors in the base model specification. The majority of the estimates indicate the coefficient on tract density is positive. This finding provides some support for the assumption that an increase in local population density causes higher levels of social interaction with friends. The number of people in whom an individual confides, the number of friends, and socializing with friends in public places are all significantly positively related to tract density. For an example of the size of this effect, consider that an increase in local population density at the average by 10 percent increases the amount of socializing with friends in public from around once a month to just under three times a month.

The findings show that talking with neighbors and the number of neighbors an individual knows significantly decrease with density. These results tell an interesting story. If the individual resides in a lower density area, the suburbs for example, he seems to interact more with neighbors than when located in a dense urban setting. Perhaps indicating neighbors are more important connections in areas of lower density than in more compressed areas. I also provide the second-order effects of density on social interaction that come from a separate level-level specification. I interpret these second-order effects as increasing (positive) or decreasing (negative) with density.

Table 2: First Stage Regression

Specification Dependent Variable: Tract Population Density	Base Model	Full Model
	Coeff.	Coeff.
Landslide Hazard	-0.057	0.004
	(0.139)	(0.077)
Seismic Hazard	0.005	0.069***
	(0.030)	(0.025)
High Seismic Hazard	1.031***	1.986***
	(0.387)	(0.625)
Seismic Hazard Interaction	-0.002	-0.065***
	(0.030)	(0.026)
% Sedimentary Rock	0.680***	0.419
	(0.158)	(0.277)
Constant	7.325***	6.957***
	(0.310)	(0.539)
N	21902	21405
Number of Clusters	311	311
Partial R^2	0.151	0.323
Instrument Tests		
F-Statistic	25.07	51.89
Kleibergen-Paap underiden. rk LM-Statistic	7.81	4.24
p-value	0.1671	0.5155
Kleibergen-Paap rk weak inden. F-Statistic	25.07	4.10
p-value	-	-
Anderson-Rubin weak instrument F-Statistic	3.42	2.01
p-value	0.005	0.0772

Note: The base model does not contain the vector of other control variables, whereas the full model contains the additional control variables. *, **, *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

By using the full model, one loses most of the statistical significance. The lack of exogenously determined control variables creates a problem. Density choice may depend upon income, marital status, or other controls, and if the inclusion of those covariates is also correlated with social interaction, it creates a bad control problem bias or proxy control bias (Angrist and Pischke, 2008). The inclusion of these controls may increase the likelihood of causal interpretation by removing some omitted variable bias. However, one could also consider these controls to be outcomes that depend upon social interaction and/or population density, which may confound the result of interest. If the instruments are effective, they are controlling for the omitted variable bias and endogeneity in the base model, leaving a consistent coefficient of interest.

Table 3: Tract Density and Friendship-Oriented Social Interaction

Specification	Base Model					
Dependent Variable	*#NEITALK*	*NEITALK*	*CONFIDE*	*FRIENDS*	*SOCPUBLIC*	*SOCHOME*
Technique	(2SLS)	(IVPROBIT)	(2SLS)	(2SLS)	(2SLS)	(2SLS)
	Coeff.	Coeff.	Coeff.	Coeff.	Coeff.	Coeff.
TRACT DENSITY	-0.157***	-0.086***	0.041*	0.074***	1.341**	0.094
	(0.049)	(0.028)	(0.024)	(0.023)	(0.626)	(0.613)
CONSTANT	6.311***	0.799***	3.190***	3.117***	5.703	21.073***
	(0.395)	(0.227)	(0.186)	(0.178)	(4.962)	(4.887)
OLS or Probit Result						
TRACT DENSITY	-0.031**	-0.012**	-0.008	-0.026**	1.045***	0.189
Hausman *p*-value	0.647	0.011	0.000	0.000	0.112	0.279
N	21902	22052	21968	21973	21971	21946
Number of Clusters	310	311	311	310	311	311
Tract Density Second Order Effect	Negative	Negative	Negative	Negative	Negative	Negative
Uncentered R^2	0.879	-	0.960	0.902	0.401	0.592
Centered R^2	0.001	-	0.007	0.003	0.001	0.001
Instrument Tests						
First Stage *F*-Statistic	25.07	-	25.63	25.18	25.22	24.92
Kleibergen-Paap rk underiden. LM-Statistic	7.809	-	7.821	7.794	7.796	7.793
p-value	0.1671	-	0.1664	0.1680	0.1678	0.1680
Kleibergen-Paap rk weak inden. *F*-Statistic	25.075	-	25.634	25.184	25.221	24.925
Stock-Yogo critical value (10%)	10.83	-	10.83	10.83	10.83	10.83
Hanson-J over ID test statistic	8.03	-	5.10	2.19	7.26	4.64
p-value	0.0905	-	0.2771	0.7018	0.1228	0.3266

Note: Base model does not include additional control variables. Tract density OLS coefficient and second order effect sign come from separate specifications. *, **, *** imply statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 4: Tract Density and Friendship-Oriented Social Interaction

Specification	Full Model					
Dependent Variable	#NEITALK	NEITALK	CONFIDE	FRIENDS	SOCPUBLIC	SOCHOME
Technique	(2SLS)	(IVPROBIT)	(2SLS)	(2SLS)	(2SLS)	(2SLS)
	Coeff.	Coeff.	Coeff.	Coeff.	Coeff.	Coeff.
TRACT DENSITY	-0.055	-0.020	0.059**	-0.001	0.667	-1.048
	(0.081)	(0.053)	(0.029)	(0.025)	(0.568)	(0.856)
MALE	0.112***	0.073***	-0.087***	0.077***	-1.556***	0.473
AGE	0.031***	0.012***	-0.010***	-0.025***	-1.319***	-1.183***
AGE2	-0.000**	-0.000	0.000***	0.000***	0.009***	0.008***
MARRD/PARTN	0.112***	0.074**	0.046**	0.009	-4.894***	-1.975***
KIDS6	0.148***	0.098***	-0.039***	-0.048**	-1.477***	-0.900***
KIDS6_17	0.064***	0.044***	-0.025***	-0.034***	-0.760***	-0.297
INC2	-0.034	-0.061*	0.034	-0.015	-0.324	0.053
INC3	0.092**	-0.016	0.102***	0.056**	1.384***	0.853**
INC4	0.147***	-0.026	0.145***	0.089***	2.807***	1.667***
INC5	0.122**	-0.010	0.149***	0.083***	3.107***	1.215*
INC6	0.157**	-0.015	0.196***	0.243***	5.086***	4.180***
SOMECOLL	0.210***	0.119***	0.147***	0.164***	2.328***	2.548***
COLLGRAD	0.206***	0.047	0.227***	0.268***	1.141***	0.778*
BLACK	-0.384***	-0.143***	-0.225***	-0.432***	-2.740***	-3.218***
HISPANIC	-0.552***	-0.242***	-0.327***	-0.243***	-2.479***	-5.318***
ASIAN	-0.330**	-0.156**	-0.182***	-0.236***	-3.512***	-4.120**
UNEMP	-0.107	-0.017	-0.108**	-0.098*	0.246	0.128
HOMEMAKER	0.115	0.087*	0.012	0.002	1.165	0.612
RETIRED	0.270***	0.152***	0.073**	0.181***	1.949***	2.914***
CITIZEN	0.415***	0.276***	0.138***	0.020	1.388*	4.503***
LIVING5	0.257***	0.106***	0.018	0.095***	1.705***	1.907***
PACIFIC	0.080	0.063	-0.056	0.150***	0.994	1.669*
MIDATLAN	0.085	0.124	-0.052	0.023	0.138	-0.858
EANOCENT	0.058	0.046	0.007	0.109***	1.206	-0.111
WENOCENT	0.284***	0.234***	-0.053**	0.107***	1.759***	0.463
SOUTHATL	0.030	0.039	-0.049	0.082**	-0.068	-1.666
EASOCENT	0.012	0.014	-0.013	0.160**	1.464	-2.049
WESOCENT	0.194	0.060	-0.060	0.109**	0.535	-0.225
MOUNTAIN	0.186	0.067	-0.052	0.162***	1.830**	2.689***
MURDER	0.006	0.007	-0.002	-0.001	-0.131***	-0.093
DISSIMILARITY	0.190	0.056	-0.201*	0.101	2.920	2.460
CONSTANT	3.459***	-0.781*	3.244***	3.452***	47.298***	57.909***
OLS or Probit Result						
TRACT DENSITY	0.016	0.006	0.000	-0.009	0.332***	-0.022

N	21405	21539	21483	21486	21487	21466
Number of Clusters	307	308	308	307	308	308
Tract Density Second Order Effect	Positive	Positive	Negative	Positive	Negative	Negative
Uncentered R^2	0.888	-	0.954	0.910	0.509	0.565
Centered R^2	0.075	-	0.066	0.073	0.178	0.110
Instrument Tests						
First Stage *F*-Statistic	51.89	-	54.53	55.3	56.17	54.91
Kleibergen-Paap rk under-iden. LM-Statistic	4.24	-	4.32	4.26	4.27	4.25
p-value	0.5155	-	0.5040	0.5133	0.5117	0.5137
Kleibergen-Paap rk weak inden. *F*-Statistic	4.10	-	4.08	4.14	4.12	4.11
Stock-Yogo critical value (10%)	10.83	-	10.83	10.83	10.83	10.83
Hanson-*J* over ID test statistic	4.45	-	3.65	3.14	2.77	0.40
p-value	0.3482	-	0.4554	0.5339	0.5998	0.9828

Note: Tract density OLS coefficient and second order effect sign come from separate specifications. *, **, *** imply statistical significance at the 10%, 5%, and 1% levels, respectively.

As Table 4 shows, the neighbor interactions still yield negative but not significantly negative results. The number of confidants is the only significant positive relationship remaining. Density is negatively related to both the number of friends and how often individuals socialize at home, but not significantly different from zero. Last, hanging out with friends in public places is positively related to local density.

The friends results corroborate the assumption that density causes higher levels of social interaction. I consistently find the neighbor interactions, however to have a negative or significantly negative relationship with density. These results indicate some types of social interaction are more likely in lower densities, for example suburbs may provide a better environment for neighbors to interact.

The friends and neighbors results tables also report the instrument tests. The first stage F-statistic is high in all specifications. The Kleibergen-Paap test statistics are also large, signifying low concern for underidentification and weak instruments. I use the Stock and Yogo (2005) critical values for weak instrument tests since no critical values are available when clustering the standard errors. In almost all cases, I fail to reject the overidentifying restrictions, as the Hansen-J statistics are close to zero. These tests provide evidence that the geological instruments are exogenously determined and sufficiently strong. Additionally, the OLS (Ordinary Least Squares) results in the base and full models show the importance of the instruments. In most cases, the OLS framework produces reduced magnitudes of the estimated coefficients.

5.3 Group Involvement Results

Table 5 reports the results for group involvement interaction and population density in the base model. The results for social interaction involving groups, participation in a hobby club, or neighborhood cooperation yield essentially no relationship with local population density. The number of club meetings respondents attend is negatively linked to density and is the only

Table 5: Tract Density and Group-Involvement Social Interaction

Specification	Base Model			
Dependent Variable	NEICOOP	HOBBYCLUB	CLUBMTGS	#GROUPS
Technique	(IVPROBIT)	(IVPROBIT)	(2SLS)	(2SLS)
	Coeff.	Coeff.	Coeff.	Coeff.
TRACT DENSITY	-0.024	-0.037	-0.405**	-0.073
	(0.042)	(0.043)	(0.178)	(0.081)
CONSTANT	-0.291	-0.383	9.024***	3.451***
	(0.333)	(0.335)	(1.437)	(0.630)
OLS or Probit Result				
TRACT DENSITY	-0.002	-0.020**	-0.144*	-0.002
Hausman *p*-value	0.670	0.400	0.239	0.994
N	10843	22020	22005	22052
Number of Clusters	257	311	311	311
Tract Density Second Order Effect	Positive	Positive	Positive	Positive
Uncentered R^2	-	-	0.192	0.5517
Centered R^2	-	-	0.001	0.001
Instrument Tests				
First Stage F-Statistic	-	-	25.21	25.13
Kleibergen-Paap rk underiden. LM-Statistic	-	-	7.80	7.80
p-value	-	-	0.1679	0.1678
Kleibergen-Paap rk weak inden. F-Statistic	-	-	25.21	25.13
Stock-Yogo critical value (10%)	-	-	10.83	10.83
Hanson-J over ID test statistic	-	-	5.70	5.06
p-value	-	-	0.2229	0.2817

Note: Base model does not include additional control variables. Tract density OLS coefficient and second order effect sign come from separate specifications. *, **, *** imply statistical significance at the 10%, 5%, and 1% levels, respectively.

statistically significant relationship. These results show population density has little impact the intensity of group involvement. Group interaction usually takes more advanced planning to establish, and the level of planning may be consistent across different levels of density.

Table 6 provides the full model results. The estimation shows an association among membership in a hobby club and attendance of club meetings statistically decrease with increased population density. The remaining two estimates show a positive relationship between neighborhood cooperation and density and a negative relationship between the number of groups and density. Perhaps the cost of gathering for these meetings or establishing these groups increases with higher density.

The friends and neighbors and group involvement results yield different views of the relationship between social interaction and local population density. Inadequate instruments might underlie the previous findings. The friends results link social interaction and density positively, while the

Table 6: Tract Density and Group-Involvement Social Interaction

Specification	Full Model			
Dependent Variable	*NEICOOP*	*HOBBYCLUB*	*CLUBMTGS*	*#GROUPS*
Technique	(IVPROBIT)	(IVPROBIT)	(2SLS)	(2SLS)
	Coeff.	Coeff.	Coeff.	Coeff.
TRACT DENSITY	0.034	-0.031**	-0.725***	-0.119
	(0.079)	-0.014	(0.260)	(0.076)
MALE	0.118***	0.176***	-0.498**	0.166***
AGE	0.024***	0.005	-0.267***	0.015*
AGE2	-0.000***	-0.000*	0.002***	-0.000
MARRD/PARTN	0.073*	-0.048*	-0.949***	-0.006
KIDS6	0.022	-0.028	-0.357*	0.004
KIDS6_17	0.049***	-0.018	0.537***	0.281***
INC2	-0.076	-0.090**	-0.337	0.006
INC3	-0.010	0.041	0.223	0.314***
INC4	0.026	0.068**	0.579**	0.403***
INC5	0.094*	0.138***	-0.031	0.552***
INC6	0.179***	0.237***	1.461***	1.024***
SOMECOLL	0.280***	0.333***	2.380***	0.986***
COLLGRAD	0.295***	0.426***	4.086***	1.731***
BLACK	0.133**	-0.031	-0.453	0.665***
HISPANIC	0.024	-0.125**	-1.095***	-0.056
ASIAN	-0.135	-0.103	-1.762***	-0.258**
UNEMP	-0.212**	-0.155*	-0.413	-0.407***
HOMEMAKER	0.029	-0.001	0.695	-0.234***
RETIRED	-0.063	0.145***	0.289	-0.074
CITIZEN	0.270***	0.176***	1.719***	0.582***
LIVING5	0.208***	0.087***	0.845***	0.381***
PACIFIC	-0.153*	0.020	0.824*	0.169
MIDATLAN	-0.314***	-0.058	-0.505	-0.261*
EANOCENT	-0.195*	-0.012	-0.258	-0.087
WENOCENT	0.091	0.025	1.456***	0.110
SOUTHATL	-0.086	0.016	-0.184	-0.010
EASOCENT	-0.137	-0.090	-0.726	-0.059
WESOCENT	-0.164	-0.029	0.997	-0.138
MOUNTAIN	-0.059	0.113*	1.406**	0.232
MURDER	-0.014**	-0.007	0.020	-0.011*
DISSIMILARITY	0.351	0.367*	1.849	1.035**
CONSTANT	-2.131***	-1.239***	12.917***	0.499

OLS or Probit Result

TRACT DENSITY	0.011	-0.014*	-0.074	0.026*
N	10592	21514	21513	21539
Number of Clusters	255	308	308	308
Tract Density Second Order Effect	Positive	Positive	Positive	Positive
Uncentered R^2	-	-	0.221	0.619
Centered R^2	-	-	0.035	0.147
Instrument Tests				
First Stage F-Statistic	-	-	55.12	0.55
Kleibergen-Paap rk underiden. LM-Statistic	-	-	4.24	4.25
p-value	-	-	0.5149	0.5138
Kleibergen-Paap rk weak inden. F-Statistic	-	-	4.09	4.09
Stock-Yogo critical value (10%)	-	-	10.83	10.83
Hanson-J over ID test statistic	-	-	4.71	4.99
p-value	-	-	0.3184	0.2885

Note: Tract density OLS coefficient and second order effect sign come from separate specifications. *, **, *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

findings show that interactions with neighbors and group involvement decrease with higher density. The measurement of social interaction may also become an important dynamic in the relationship uncovered, as social interaction is general in definition.

5.4 Index Results

In order to broaden the scope of social interaction, I use several index measures in the same manner as the previous dependent variables. This method reduces the number of variables of interest while keeping the existing variability, and tests a more general definition of social interaction. The drawback is the indices are not created from the exact 10 social interaction variables used in the rest of the study and may not exactly portray social interaction as defined here. These index measures contain several different types of interaction, which individually may respond differently to changes in density. The assumption that social interaction and population density are positively related does not specify the particular form of interaction, so index measure may be useful in the analysis. The empirical test is identical to the other social interaction measures.

Table 7 shows the relationship between census tract density and the social interaction indices for the base model. The results, in general, indicate that the type of social interaction matters. Civic participation is positively linked to density, whereas social trust is negatively related to density. Diversity of friendship has a significantly positive relationship with density; interaction with a more diverse group of people appears to occur more in higher density areas of cities. The faith-based interaction index yields the remaining statistically significant negative relationship. Church attendance or belonging to a faith-based institution is negatively affected by additional population density.

Table 7: Tract Density and Index Measures of Social Interaction

Specification	Base Model			
Dependent Variable	*SOCTRUST*	*FAITHBAS*	*CIVICPART*	*DIVERSITY*
Technique	(2SLS)	(2SLS)	(2SLS)	(2SLS)
	Coeff.	Coeff.	Coeff.	Coeff.
TRACT DENSITY	-0.004	-0.168***	0.017	0.227***
	(0.037)	(0.030)	(0.071)	(0.082)
CONSTANT	-0.009	1.250***	1.516***	5.192***
	(0.286)	(0.246)	(0.552)	(0.648)
OLS or Probit Result				
TRACT DENSITY	-0.072***	-0.060**	0.019	0.030
N	21955	21839	22051	22046
Number of Clusters	311	311	311	311
Tract Density Second Order Effect	Negative	Positive	Negative	Negative
Uncentered R^2	0.475	0.573	0.633	0.841
Centered R^2	0.032	0.129	0.021	0.007
Instrument Tests				
First Stage F-Statistic	25.4	25.53	25.13	25.1
Kleibergen-Paap rk underiden. LM-Statistic	7.77	7.80	7.80	7.79
p-value	0.1696	0.1679	0.1679	0.1681
Kleibergen-Paap rk weak inden. F-Statistic	25.40	25.53	25.13	25.10
Stock-Yogo critical value (10%)	10.83	10.83	10.83	10.83
Hanson-J over ID test statistic	4.25	6.28	2.02	3.14
p-value	0.3734	0.1791	0.7317	0.5354

Note: Base model does not include additional control variables. Tract density OLS coefficient and second order effect sign come from separate specifications. *, **, *** imply statistical significance at the 10%, 5%, and 1% levels, respectively.

In the full model, shown in Table 8, the relationships lose magnitude and significance. The only significant result remaining is the negative relationship between tract density and faith-based interactions. As discussed above, each specification includes a series of tests for instrument strength. Many tests of instrument strength indicate again little worries of weak instruments.

6. CONCLUSIONS

This paper examines the causal relationship between local population density and social interaction. I provide an empirical test to determine the plausibility of a common assumption that the link is positive. I advance the previous empirical efforts by purging the endogeneity between social interaction and population density.

Table 8: Tract Density and Index Measures of Social Interaction

Specification				
Dependent Variable	*SOCTRUST*	*FAITHBAS*	*CIVICPART*	*DIVERSITY*
Technique	(2SLS)	(2SLS)	(2SLS)	(2SLS)
	Coeff.	Coeff.	Coeff.	Coeff.
TRACT DENSITY	0.004	-0.089*	-0.017	0.076
	(0.014)	(0.049)	(0.052)	(0.096)
MALE	-0.060***	-0.117***	-0.049***	-0.064
AGE	0.012***	0.003	0.034***	0.045***
AGE2	-0.000*	0.000	-0.000***	-0.001***
MARRD/PARTN	0.050***	0.048***	0.001	0.151***
KIDS6	-0.030***	0.042***	-0.023	-0.019
KIDS6_17	-0.002	0.071***	0.061***	0.037
INC2	-0.001	-0.016	-0.002	-0.013
INC3	0.082***	0.011	0.131***	0.382***
INC4	0.119***	0.026	0.231***	0.519***
INC5	0.129***	0.026	0.245***	0.540***
INC6	0.154***	0.021	0.349***	0.838***
SOMECOLL	0.148***	0.181***	0.525***	0.977***
COLLGRAD	0.312***	0.263***	0.892***	1.156***
BLACK	-0.493***	0.275***	0.063	-0.153*
HISPANIC	-0.413***	0.152***	-0.150***	-0.377***
ASIAN	-0.154***	0.063	-0.594***	-1.105***
UNEMP	-0.091***	-0.044	-0.171***	-0.346**
HOMEMAKER	0.077***	0.116***	-0.055*	-0.520***
RETIRED	0.045*	0.056**	-0.031	-0.224***
CITIZEN	0.092***	0.099***	0.783***	1.327***
LIVING5	0.017	0.114***	0.154***	0.165***
PACIFIC	0.030	0.017	0.063	0.220
MIDATLAN	0.094**	0.027	-0.245***	-0.313
EANOCENT	0.104***	0.053	-0.153*	-0.228
WENOCENT	0.088***	0.110**	-0.021	-0.047
SOUTHATL	0.041	0.116	-0.196**	-0.112
EASOCENT	0.076	0.163	-0.184	-0.347
WESOCENT	0.031	0.163**	-0.277***	-0.096
MOUNTAIN	0.024	-0.026	0.127	0.239
MURDER	-0.008***	0.003	-0.010	-0.020**
DISSIMILARITY	-0.152**	0.282	0.493	0.274
CONSTANT	-0.601***	-0.254	-0.564	2.674***

OLS or Probit Result				
TRACT DENSITY	-0.035***	-0.028***	0.035***	0.050***
N	21449	21373	21538	21534
Number of Clusters	308	308	308	308
Tract Density Second Order Effect	Negative	Positive	Negative	Positive
Uncentered R^2	0.246	0.113	0.715	0.864
Centered R^2	0.244	0.099	0.222	0.136
Instrument Tests				
First Stage *F*-Statistic	57.69	57.66	55.43	55.45
Kleibergen-Paap rk underiden. LM-Statistic	4.25	4.25	4.25	4.25
p-value	0.5140	0.5136	0.5139	0.5147
Kleibergen-Paap rk weak inden. F-Statistic	4.07	4.12	4.09	4.09
Stock-Yogo critical value (10%)	10.83	10.83	10.83	10.83
Hanson-J over ID test statistic	1.73	12.07	6.18	4.27
p-value	0.7850	0.0168	0.1860	0.3703

Note: Tract density OLS coefficient and second order effect sign come from separate specifications. *, **, *** imply statistical significance at the 10%, 5%, and 1% levels, respectively.

Using a set of exogenously determined instrumental variables, I find the type of social interaction matters when determining its relationship with population density. Social interaction involving friends tends to be positively related with local population density. Social interaction with neighbors or groups largely decreases as population density increases, and the more generally defined index measures of social interaction yield mixed results of the relationship between interaction and population density.

While the scope of this paper was not to analyze the economic impacts of social interaction resulting from higher population density, the results provided do lead to some interesting discussion points. Granovetter (1973) puts significant weight on the strength of weak ties. These weak ties allow the diffusion of information and influence to spread quickly among a large set of groups. If the economic impacts from additional social interaction are drawn through the dissemination of information about, for example, jobs, health benefits, or financial opportunities then weak ties are relevant. Some may consider friends, neighbors and groups weak ties or bridge connections across groups. The implication of this argument and this paper suggests that the friend interaction channel provides spreading of information more readily at higher levels of population density whereas at lower levels of population density neighbors and groups will provide greater economic impact from diffusion of information across groups.

Another implication of these findings, following Bellair (1997), suggest lower density areas that have frequent, or even infrequent, interaction between neighbors can significantly reduce certain crime rates. Burglary, motor vehicle theft, and robbery rates decline when neighbors come together at least once a year. As residents come to know one another, they may willingly participate in supervision of neighbors' property. These implications of the relationships found in this paper are only a few of a larger set of economic impacts derived from the social environment of urban areas.

REFERENCES

Abel, Jaison R., Ishita Dey, and Todd M. Gabe. (2012) "Productivity and the Density of Human Capital," *Journal of Regional Science*, 52, 562–586.

Angrist, Joshua D. and Jörn-Steffen Pischke. (2008) *Mostly Harmless Econometrics: An Empiricist's Companion*. Princeton University Press: New Jersey.

Bayer, Patrick J., Randi J. Hjalmarsson, and David Pozen. (2009) "Building Criminal Capital Behind Bars: Peer Effects in Juvenile Corrections," *Quarterly Journal of Economics*, 124, 105–47.

Bellair, Paul E. (1997) "Social Interaction and Community Crime: Examining the Importance of Neighbor Networks," Criminology, 35, 677–704.

Briggs, Xavier de Souza. (2008) *Democracy as problem solving: Civic capacity in communities across the globe.* The MIT Press: Cambridge.

Brueckner, Jan K. and Ann G. Largey. (2008) "Social Interaction and Urban Sprawl," *Journal of Urban Economics*, 64, 18–34.

Durkheim, Emile. (1933) *The Division of Labor*. Trans. G. Simpson. Macmillan: New York.

Ellison, Nicole B., Charles W. Steinfield, and Cliff Lampe. (2007) "The Benefits of Facebook "Friends": Social Capital and College Students' Use of Online Social Network Sites," *Journal of Computer-Mediated Communication*, 12, 1143–1168.

Glaeser, Edward L. and Joshua D. Gottlieb. (2006) "Urban Resurgence and the Consumer City," *Urban Studies*, 43, 1275–99.

Granovetter, Mark S. (1973) "The Strength of Weak Ties," *American Journal of Sociology*, 78, 1360–1380.

_____. (2005) "The Impact of Social Structure on Economic Outcomes," *Journal of Economic Perspectives*, 19, 33–50.

Helsley, Robert W. and Yves Zenou. (2011) "Social Networks and Interactions in Cities," *IZA Discussion Paper No. 5506*.

Hilber, Christian A.L. (2010) "New Housing Supply and the Dilution of Social Capital," *Journal of Urban Economics*, 67, 419–437.

Hogler, Raymond L., Steven J. Shulman, and Stephan Weiler. (2004) "Right-to-Work Legislation, Social Capital, and Variations in State Union Density," *The Review of Regional Studies*, 34, 95–111.

Hong, Harrison G., Jeffrey D. Kubik, and Jeremy C. Stein. (2004) "Social Interaction and Stock-Market Participation," *The Journal of Finance*, 59, 137–163.

Israel, Glenn D. and Lionel J. Beaulieu. (2004) "Laying the Foundation for Employment: The Role of Social Capital in Educational Achievement," *The Review of Regional Studies*, 34, 260–287.

Jacobs, Jane. (1961) *The Death and Life of Great American Cities*. Random House: New York.

Jones, Andrew M. (1994) "Health, Addiction, Social Interaction and the Decision to Quit Smoking," *Journal of Health Economics*, 13, 93–110.

Manski, Charles F. (2000) "Economic Analysis of Social Interactions," *Journal of Economic Perspectives*, 14, 115–36.

Rosenthal, Stuart S. and William C. Strange. (2004) "Evidence on the Nature and Sources of Agglomeration Economies," Handbook of Regional and Urban Economics, 4, 2119–2171.

Rosenthal, Stuart S. and William C. Strange. (2008) "The Attenuation of Human Capital Spillovers," *Journal of Urban Economics*, 64, 373–89.

Simmel, Georg. (1964). The Metropolis and Mental Life. *The Sociology of George Simmel*. Wolff, Kurt. Free Press: New York, pp.409–424.

Stock, James H. and Motohiro Yogo. (2005) Asymptotic Distributions of Instrumental Variables Statistics with Many Instruments. In: Andrews, D.W.K., Stock, J.H. (Eds.), *Identification and Inference for Econometric Models: A Festschrift in Honor of Thomas J. Rothenberg*, Cambridge University Press: Cambridge, UK, pp. 109–120.

Trogdon, Justin G., James M. Nonnemaker, and Joanne M. Pais. (2008) "Peer Effects in Adolescent Overweight," *Journal of Health Economics*, 27, 1388–1399.

Winsborough, Halliman H. (1965) "The Social Consequences of High Population Density," *Law and Contemporary Problems*, 30, 120–126.