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Are Gasoline Prices a Factor in Residential Relocation Decisions? Preliminary Findings from the American Housing Survey, 1996–2008

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Abstract

Residential relocation choice is affected by numerous factors, but gasoline prices as a potential factor have not been investigated. This study examines gasoline price changes and residential relocation choice using 1996–2008 American Housing Survey data. We found higher gasoline prices are associated with a higher percentage of movers choosing locations closer to workplaces. The findings have implications for addressing the impacts of volatile gasoline prices on land use planning and policies; resilient "smart cities or communities" are one possible solution.

Keywords

gasoline price, residential location, smart city, smart community, American Housing Survey

Introduction

A large body of literature across a variety of disciplines has examined residential location choice and its influential factors, including life-course events and household structure changes (e.g., Clark and Onaka 1983; Lee 1966; Shuttleworth and Gould 2010), the housing market (e.g., Clark and Dieleman 1996; Dong 2015; Lee and Myers 2003), the job market (e.g., Greenwood 1975), and access to work or school (e.g., Clark, Huang, and Withers 2003; Korsu 2012; Rouwendal and Meijer 2001).

However, the possible linkage between gasoline prices and residential location, which has not been investigated, is a topic worthy of study: people are sensitive to changes in gasoline prices not only because people could see prices from roadside gas stations everyday but also because those prices have an immediate effect on monthly household expenses. An increase in gasoline prices raises the cost of driving, including travel to work, which is a nondiscretionary expense for most people. Although people could move closer to work to reduce that cost, gasoline price increases are rarely the sole reason for relocating one's household: on average, annual expenditures on gasoline are less than 10 percent of the moving cost (Molloy and Shan 2013). Nevertheless, for those who do move, gasoline prices could become a consideration when selecting residential locations because, over the long term, gasoline expenditure and travel distance have a significant effect on the quality of life (Molloy and Shan 2013).

The primary objective of this preliminary study is to examine and explain the possible relationship of gasoline prices to residential location choice using the 1996–2008 American Housing Survey (AHS) data. This preliminary study contributes to the literature on urban form and residential relocation decision-making by investigating the impact of gasoline price changes on residential location. If the results support our hypothesis, which is that higher gasoline prices influence movers to select locations closer to workplaces, it would have important policy implications: that higher gasoline prices lead to centralization and high-density development—the reverse of the decentralization process and low-density sprawl that have been experienced in the past two centuries or so (Anderson, Kanaroglou, and Miller 1996); and that "smart cities/communities" are more resilient to gasoline price changes (Lee and Lee 2013). These results would have substantial impacts on human society from the perspectives of urban and regional planning, land use planning, transportation planning, firm location, public resource allocation, social equity, and others.

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Prior Research

Energy Effects on Urban Form and Land Use

The first body of literature, which was published primarily in the 1980s and 1990s, addresses the effects of energy sources such as gasoline on urban form and land use. Following the energy crisis in the late 1970s, a limited number of studies examined energy effects on urban form and land use and identified the most energy-efficient urban form. Although some studies argued that energy scarcity has limited effects on urban form (Haines 1986; Lave 1978; Small 1980), other studies suggested that energy prices have significant impacts on urban form (Banister 1992; Holden and Norland 2005; Kenworthy and Newman 1990; Newman and Kenworthy 1989). In a study examining transport energy use in British urban communities, Banister (1992) found that the most energy-efficient urban form is polycentric. A report from the Council on Environmental Quality (1975) noted that centralized or high-density areas decrease dependence on automobiles, thus reducing transportation-related costs. According to Newman and Kenworthy (1989) and Kenworthy and Newman (1990), urban form and density shape energy use for transportation purposes, namely, gasoline consumption. Specifically, they found an inverse relationship between urban density and gasoline use per capita, noting that gasoline consumption is lowest among central city residents. In other words, higher population density results in lower gasoline consumption.

However, this line of research has been rarely updated in the past 20 years. Although the urban form in the United States has generally been decentralization and low-density sprawl for the past two centuries or so, the pattern has exhibited variations. For example, population redistribution patterns and urban form changed from a rural renaissance in the 1970s to renewed metropolitan growth in the 1980s to a rural rebound in the 1990s to selective de-concentration in the 2000s (Johnson 1999). The increasing appreciation for natural amenities and improvements in transportation infrastructure and communication technology have helped enable these changes (Isserman, Feser, and Warren 2009). Now, with the fluctuation of gasoline prices, how might population redistribution patterns and urban form change? It is important to understand the relationship of gasoline prices to residential location and urban form in this new context.

Commuting, Housing, and Moving

The second body of literature, which is large and rooted in urban economics (Alonso 1964; McCann 2001; McFadden 1978), addresses intra-urban relocation based on the trade-off relationship between the transportation cost and housing cost. Individuals and households choose their residential location by maximizing a utility function of their demographic and socioeconomic characteristics (e.g., life course and income), housing characteristics (e.g., housing costs), locational attributes (e.g., amenities), and accessibility (e.g., transportation costs). Since gasoline expenditure directly reflects on transportation costs, a considerable change in gasoline prices would break the balance between transportation and housing costs and consequently the equilibrium of residence and workplaces. This would create the possibility of residential relocation. This body of literature addresses commuting, housing, and moving from at least five perspectives.

First, there exists a trade-off relationship between transportation and housing costs (e.g., Day and Cervero 2010; Mattingly and Morrissey 2014; Rouwendal and Meijer 2011). This applies to both metropolitan and nonmetropolitan areas (Karlsson 2011). Transportation costs are found to be an important factor in selecting residential location in the Netherlands when measured by toll and gasoline costs (Tillema, van Wee, and Ettema 2010) and in New York City when measured by travel distance (Salon 2009). Movers prefer locations with affordable housing costs and easy access to workplaces.

Second, residential location is associated with journey to work (measured by both travel time and distance). Although a few studies found that the journey to work has only a minor role in residential location choices (e.g., Giuliano and Small 1993; Kim 2008), most studies found that the journey to work is influential in residential location (e.g., Clark and Burt 1980; Coulson and Engle 1987; Korsu 2012; Levine 1998; Levinson and El-Geneidy 2009; Rietveld and Wagtendonk 2004). In a study of commuting in the Washington, DC, metropolitan area, Levinson (1998) found that housing accessibility resulting from the suburbanization of jobs leads to a shorter journey to work. Thus, when both suitable housing and jobs are available and balanced, transportation costs linked to commuting are reduced.

Third, an increase in transportation costs could lead to residential relocation. Movers with greater distances between their original residences and workplaces tend to select new residences closer to their workplaces (Clark, Huang, and Withers 2003; Ibeas et al. 2013). Anas and Hiramatsu (2012) find that gasoline price increases lead to higher transportation costs, which in turn encourages movers to select locations closer to work.

Fourth, residences and workplaces are treated as joint in some existing studies examining transportation costs and residential relocation (e.g., Ibeas et al. 2013; Lee and Waddell 2010; So, Orazem, and Otto 2001; Van Ommeren, Rietveld, and Nijkamp 1999). In other words, where to live and where to work are joint decisions that individuals and households make by balancing income, housing costs, and transportation costs, among other demographic and socioeconomic characteristics, housing characteristics, and locational attributes.

Fifth, migration decision-making due to the dynamics between transportation costs and residential relocation is further complicated by the type of household. Migration decision making among dual-income households differ from those among one-worker households. In the former, the household members would not only consider the incomes and job opportunities for both workers in the location they plan to move to, but they would also pay more attention to the work–life balance, which is more difficult to achieve than in a one-worker household (Bailey, Blake, and Cooke 2004). Typically, the earnings and career options of married women tend to move downward with a move, while those of married men tend to move upward; the exception exists for college-educated wives married to husbands who are not college educated (McKinnish 2008).

Hypothesis on Gasoline Prices and Residential Location

On the basis of our literature review, we argue that higher gasoline prices increase transportation costs, which in turn encourage movers who are more vulnerable to those price increases to relocate closer to workplaces to save travel costs. A considerable amount of the existing literature suggests that transportation cost is an important determinant of location decisions for households (e.g., Alonso 1964; Fujita and Ogawa 1982; Haggett, Cliff, and Frey 1977; Lucas and Rossi-Hansberg 2002; Mills 1967; Roback 1982). Households prefer locations with low land costs and easy access to both high-wage jobs and urban amenities in urban areas and natural amenities in rural areas (Isserman 2001). Convenient highway networks and wide use of personal vehicles allow people to live farther away from their workplaces while enjoying a low cost of living and high quality of life in suburban areas, and even in rural areas adjacent to metro areas (Chi 2012).

However, when gasoline prices increase, travel costs to workplaces increase. Travel costs can be reduced through several mechanisms: changing driving behaviors (slow acceleration, slow braking, and low speed), reducing discretionary trips, switching from frequent single-purpose trips to more multi-purpose trips, switching from personal vehicles to public transportation or carpooling, purchasing fuel-efficient vehicles, and relocating closer to workplaces (Chi et al. 2010; Small 1980). Among these mechanisms, relocating closer to workplaces as a possible means of reducing travel costs has not been investigated. We hypothesize that gasoline price increases have an impact on residential location choices by inducing movers to select locations closer to their places of employment in order to reduce travel costs.

Because of the gap in the existing literature, it is important to examine the potential effects of gasoline prices on residential location. If our results support the hypothesis that higher gasoline prices influence movers to select locations closer to workplaces, there would be important policy implications—that higher gasoline prices lead to the centralization process and high-density development, the reverse of the decentralization process and low-density sprawl that has occurred for a long time; and that "smart cities/communities" are more resilient to gasoline price changes.

Data

This preliminary study examines the relationship between gasoline prices and residential location at the monthly level from 1996–2008 using data derived from the national sample of the American Housing Survey (AHS), which is a longitudinal survey of housing units in the United States that asks respondents about their residential locations during the 24 months prior to the survey. For the national sample, the same housing units from previous surveys plus newly constructed housing units are surveyed every odd-numbered year from May through September. More than 50,000 households are surveyed at each survey administration. Each household in the AHS sample is assigned a weight, which measures the number of households it represents. The weight considers the probability of a household being selected, the change of sample size over the years, nonresponsive interviewees, new construction, and demographic adjustment (US Department of Housing and Urban Development 2012). On average, each household in the AHS sample represents itself and more than two thousand other households. We use the weighted samples for all the analyses.

Because of the similarity in the survey designs and questions asked of residential movers, which allows for the consistency of data measures, our study uses the national AHS samples collected in 1997, 1999, 2001, 2003, 2005, 2007, and 2009. The national samples of 1997–2009 cover residential location information from September 1995 to June 2009. The data for 1995 and 2009 are removed from the analysis for the convenience of examining annual averages and for eliminating the possible seasonal variation of residential relocation. Therefore, our final data set consists of 156 (12 × 13) observations with residential relocation information from January 1996 through December 2008. We provide Table 1 to illustrate the demographic characteristics of the movers in the study period. Of the movers, slightly more were female (51.7 percent), the majority (62.3 percent) were non-Hispanic white, and the majority (48.3 percent) were married. The race/ethnicity of movers reflected demographic changes in the United States during the time period, with a decreased proportion of non-Hispanic whites and increased proportions of non-Hispanic blacks and Hispanics. While movers tended to have at least a high school degree (84.7 percent), slightly more held at least a bachelor's degree (30.6 percent), reflecting that the educated tend to be movers. The average age among movers eighteen or older was 42.2 years.

The AHS also collects the reasons for residential relocation. If a respondent has moved in the 24 months prior to the interview, the AHS gathers the reason for moving from the previous residence and the reason for choosing the present residence or neighborhood. The percentages of movers and their reasons are presented in Figure 1. Among the reasons for moving from the previous residence, *closer to work/school*, which accounts for 9.4 percent of all movers, is relevant to this study because gasoline price increases push movers to select

Table 1. Descriptive Statistics for All Respondents (Weighted) by Year.

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	All Years
No. of movers (in millions)	10.7	14.6	8.7	11.4	9.7	11.7	10.0	10.0	11.1	9.9	10.3	8.8	9.3	136.1
Mean age (excluding children)	43.6	41.8	43.5	41.9	43.2	41.7	42.5	41.8	40.0	41.8	42.1	40.9	42.4	42.2
Gender														
Male, %	48.6	49.1	48.9	49.2	49.0	48.4	48.6	48.6	48.7	48.4	48.5	48.6	48.2	48.3
Female, %	51.4	50.9	51.1	50.8	51.0	51.6	51.4	51.4	51.3	51.6	51.5	51.4	51.8	51.7
Race/ethnicity														
Non-Hispanic White, %	67.8	65.5	66.0	64.7	65.0	63.0	62.5	61.8	61.9	60.1	58.9	58.1	55.8	62.3
Non-Hispanic Black, %	11.4	12.1	11.7	12.4	11.4	11.6	11.2	12.0	11.7	12.3	13.1	15.2	15.5	13.6
Hispanics, %	14.8	15.8	15.2	15.9	17.0	17.8	18.2	18.0	18.1	20.0	20.0	18.6	20.1	16.2
Others, %	6.0	6.6	7.1	7.0	6.6	7.6	8.1	8.2	8.3	7.6	8.0	8.1	8.6	7.9
Marital status														
Married, %	54.3	50.2	54.0	51.3	53.6	50.1	51.5	50.2	51.6	49.3	49.2	46.1	44.6	48.3
Divorced, %	9.3	10.7	9.7	10.1	10.3	10.6	10.7	10.4	10.5	10.5	11.5	12.1	11.8	9.9
Widowed, %	4.5	3.9	4.5	3.9	4.3	4.4	4.2	4.2	3.9	4.2	4.6	4.3	4.2	6.0
Separated, %	1.8	2.5	2.0	2.2	1.9	2.1	2.2	2.5	2.2	2.7	2.4	2.7	2.8	2.2
Never married, %	30.2	32.7	29.7	32.5	30.0	32.7	31.3	32.7	31.6	33.3	32.3	34.8	36.6	33.7
Education														
Less than high school degree, %	15.6	17.2	15.4	16.3	16.0	16.4	14.3	14.9	14.9	15.2	14.6	14.4	14.7	15.3
High school degree, %	27.9	28.5	28.2	26.7	26.7	27.0	26.5	26.8	25.7	26.1	26.4	26.2	26.1	26.9
Some college, %	29.7	28.8	28.4	29.4	29.2	29.5	29.2	28.8	28.6	29.1	29.5	30.0	29.2	27.2
Bachelor's degree or higher, %	26.8	25.5	28.0	27.7	28.0	27.2	30.1	29.5	30.8	29.6	29.4	29.4	30.0	30.6

locations closer to work/school to reduce travel costs. Accordingly, the percentage of movers who move to be closer to work/school is our first response variable. Among the reasons for choosing the present residence, *convenient to job*, which accounts for 21 percent of all movers, is also relevant to this study. Therefore, the percentage of movers who choose a residence because it is convenient to their job is our second response variable. However, it should be noted that the first response variable is our preferred one to measure residential relocation in its relationship to gasoline price changes: if higher gasoline prices are a respondent's motivating factor for relocation, he or she likely will choose to move to a location closer to work/school specifically because it will reduce travel costs. In contrast, moving to the present residence in order to be convenient to a job might be for reasons other than gasoline price changes (such as spouse's job location, wanting to increase family time, alternative transportation modes, etc.). The second response variable is used as an approximation to measure residential relocation.

The major explanatory variables of residential location in this study are gasoline prices. Data for those prices were obtained from the Energy Information Administration (EIA) of the US Department of Energy for the period 1993 through 2008 (EIA 2012). Our study uses the monthly national average price for all grades of gasoline. The price data were adjusted for inflation to January 2009 dollars using Consumer Price Index data obtained from the US Bureau of Labor Statistics (2012).

The descriptive statistics for the two response variables measuring residential relocation and the explanatory variables are presented in Table 2. The annual averages are also presented in Figure 2. Overall, the general trend of gasoline price increases is consistent with the general uptrend in the percentages of movers who relocate to be closer to work/school and to live in a location convenient to a job.

Methodology

Gasoline Prices: Changes, Moving Averages, and Lags

Existing studies suggest that the social and spatial effects of gasoline prices may occur over both the short and the long term (Chi et al. 2010; Dahl and Sterner 1991). These studies measure gasoline prices in at least three ways. First, the literature on gasoline prices and traffic safety often measures gasoline prices at specific time points such as current time, one-year lag, two-year lag, three-year lag, and four-year lag (e.g., Chi et al. 2010; Grabowski and Morrisey 2004). Second, the economic literature on gasoline prices and household locations often measures prices by their changes over time (e.g., Molloy and Shan 2013). Third, gasoline prices are also measured as moving averages in time series analyses (e.g., Fine, Busch, and Garderet 2012). In these three measures of gasoline prices, the researchers considered time lags. However, when price effects occur and how long those effects last have never been comprehensively investigated. In our study, we first examine the temporal relationship between gasoline prices and residential location choice by illustrating the correlation between changes and moving averages in gasoline prices and two

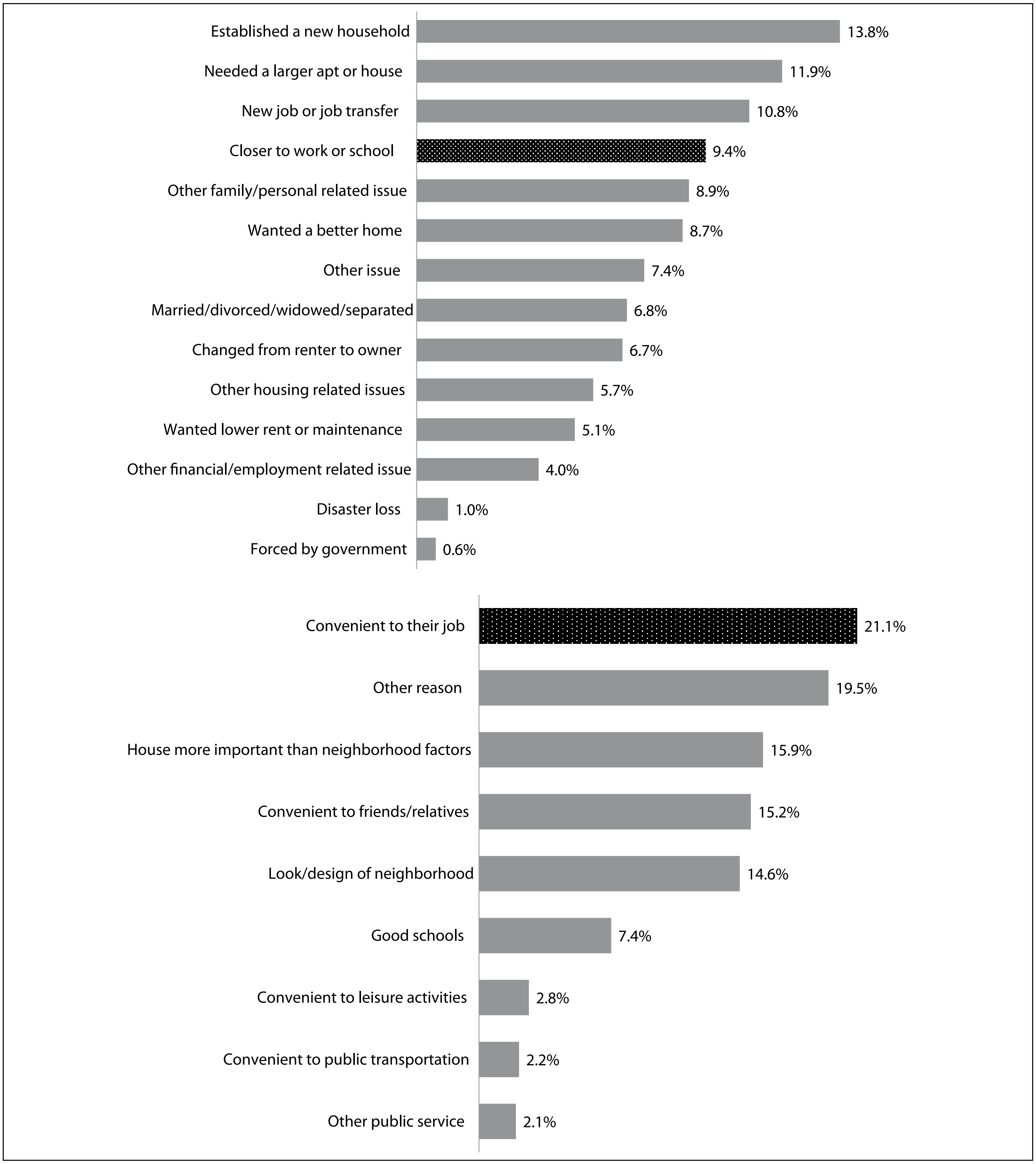

Figure 1. Reasons for moving from previous residence and for choosing present residence, 1996–2008.

residential location variables (Figure 3). Changes and moving averages in gasoline prices are measured in monthly intervals up to 48 months—that is, changes in gasoline prices are measured as changes in the past month, the past two months, and so on up to the past 48 months. Moving averages in gasoline prices are also measured as the averages of gasoline prices in the past month, past two months, etc. Because there are two residential location choice variables, 192 (48 × 2 × 2) correlations are calculated; they are graphed in Figure 3.

Table 2. Descriptive Statistics at the Monthly Level, 1996–2008.

	Mean	SD	Minimum	Maximum
Number of movers who left previous residence to be closer to work/school	78,369	52,277	15,543	382,029
Percentage of movers who left previous residence to be closer to work/school	9.4%	3.15%	3.12%	19.72%
Number of movers who selected current residence to be convenient to job	178,254	72,521	62,289	452,296
Percentage of movers who selected current residence to be convenient to job	21.14%	3.13%	13.29%	28.44%
Gasoline prices at current time (adjusted to January 2009 dollars)	$2.07	$0.63	$1.24	$4.00
Unemployment rate	5.0%	0.7%	3.8%	7.3%
Median housing price	$223,081	$24,432	$183,127	$275,032

Note: n = 156. SD = standard deviation.

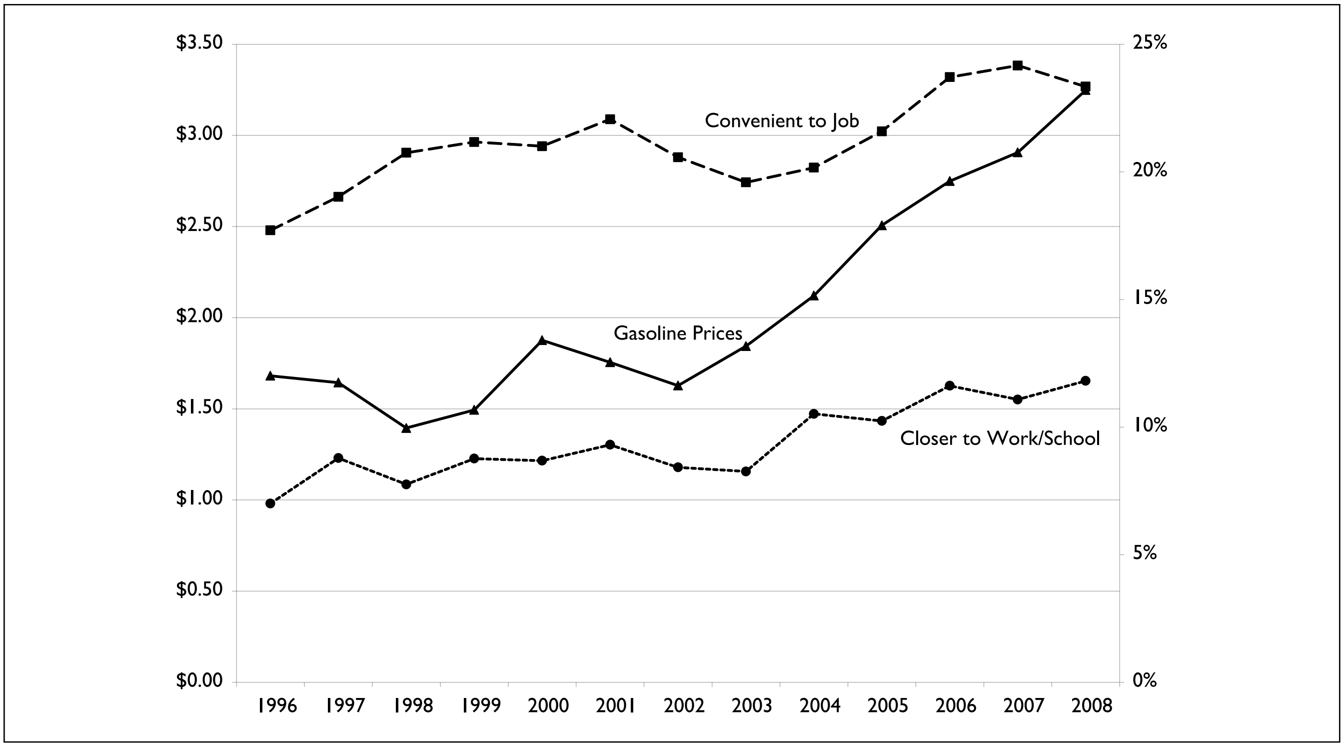

Figure 2. Trends of gasoline prices, percentage of movers relocating closer to work/school, and percentage of movers relocating to a residence convenient to a job, 1996–2008.

When the correlations between gasoline prices and residential relocation reach peaks or bottoms, the number of months lagged at which gas price is marked and labeled. The correlation between changes in gasoline prices and the percentages of movers who relocate to be closer to work/school follows a general uptrend with seasonal variations; the correlations are statistically significant at the $p \leq 0.05$ level beginning with the change in the past five months. The correlation between changes in gasoline prices and the percentages of movers who choose a residence convenient to their job also follows a general uptrend with seasonal variations; the correlations are statistically significant beginning with the change in the past 11 months.

The correlations between moving averages in gasoline prices and residential location variables are all statistically significant at the $p \leq 0.05$ level but show a less clear pattern. The correlation between moving averages in gasoline prices and the percentages of movers relocating to be closer to work/school shows a general downtrend but levels off after three years; the correlation generally peaks in the first quarter of a year and bottoms out in the third quarter. The correlation between moving averages in gasoline prices and the percentages of movers relocating to a residence convenient to their job increases slightly within the first three years but declines after that.

The observation of the correlations generally indicates that the association between changes in gasoline prices and residential location is limited to a three-year period; the higher correlation after the three-year period might be a coincidence of secular changes and seasonal variations in gasoline prices and residential location. The secular changes are that the percentages of movers relocating closer to work/

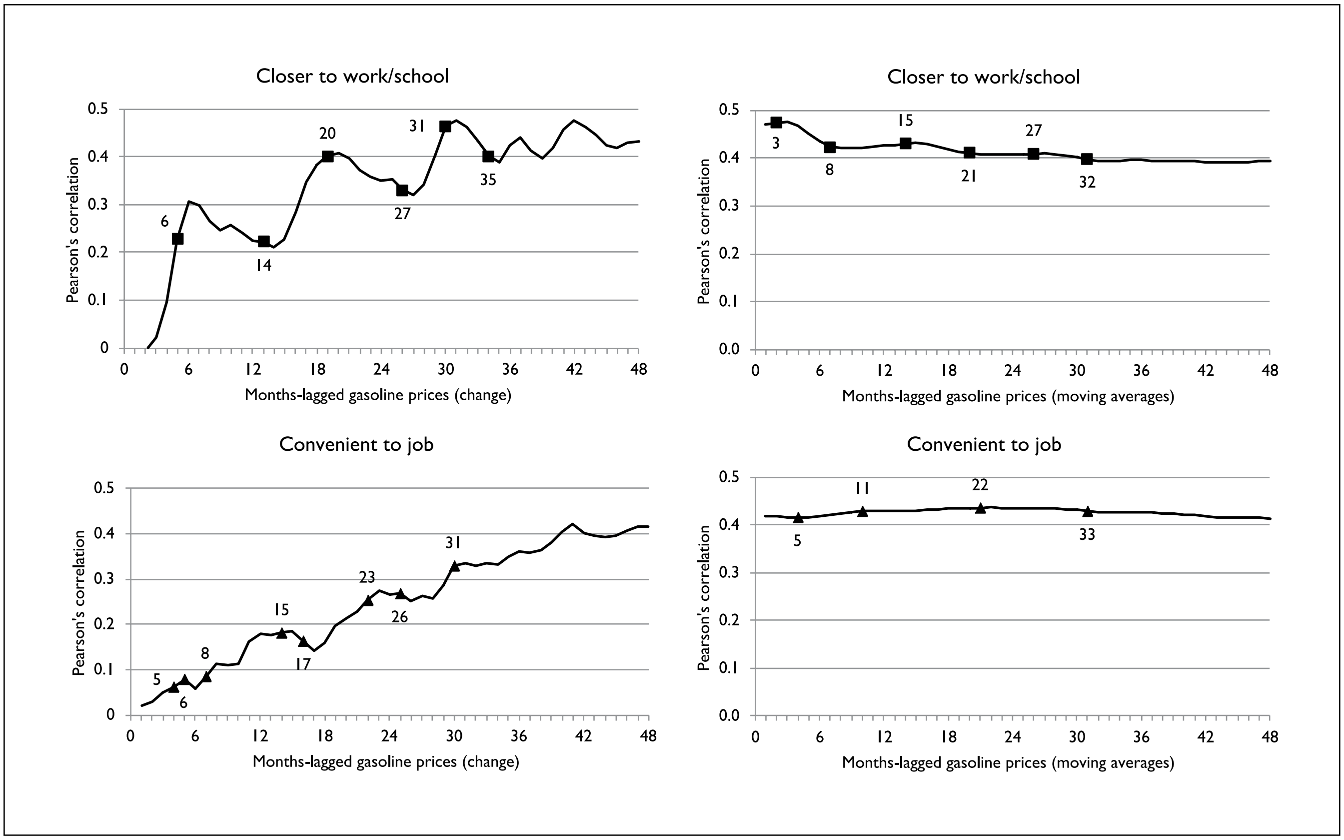

Figure 3. Correlations between lagged gasoline prices and residential location.
Note: (1) Correlations between changes in gasoline prices and the percentages of movers who relocate closer to work/school are statistically significant at the $p \leq 0.05$ level beginning with the five-month lag; correlations between changes in gasoline prices and the percentages of those who move to a location convenient to their job are statistically significant at the $p \leq 0.05$ level beginning with the 11-month lag. (2) Correlations between moving averages in gasoline prices and the two residential location variables are statistically significant at the $p \leq 0.05$ level for all months lagged.

school and for convenience to their job increase in the study period while prices are increasing. Our speculation is supported by the findings in existing studies that found gasoline prices have statistically significant effects on household locations within three years of the move (e.g., Molloy and Shan 2013). However, the threshold of the time lag should be further investigated in future research. Here we identify the reasonable time lags at which gasoline prices are associated with residential location for the purpose of including appropriate gasoline price variables in the modeling.

On the basis of the observation about the time lag, we chose to use seven gasoline price measures in our analysis: price at current time and changes and moving averages in prices at a one-year lag, a two-year lag, and a three-year lag. For instance, corresponding to residential location choice in December 2008, the concurrent gasoline price is measured as of December 2008; the change in prices at a one-year lag is measured as the difference between prices in December 2008 and December 2007, the change in prices at a two-year lag is measured as the difference between prices in December 2008 and December 2006, and the change in prices at a three-year lag is measured as the difference between prices in December 2008 and December 2005. The moving average in gasoline prices at a one-year lag is measured as the average of prices between December 2008 and December 2007, the moving average in prices at a two-year lag is measured as the average of prices between December 2008 and December 2006, and the moving average in prices at a three-year lag is measured as the average of prices between December 2008 and December 2005. Changes and moving averages in gasoline prices are used separately in models along with price at current time.

The seven measures of gasoline prices allow us to examine the possible short-term, intermediate, and long-term effects of gasoline prices on residential location. Gasoline price at current time measures the short-term or immediate effects of gasoline prices on residential location. The one-year lag variables measure the intermediate effects of prices on residential location, while the two- and three-year lag variables measure the long-term effects of prices on residential location.

Ordinary Least Squares Regression

We use gasoline price measures to examine their relationship with residential location at the monthly level by using ordinary least squares (OLS) regression models. The response variables are the percentage of movers leaving previous residence to be closer to work/school and the percentage of movers relocating to a residence convenient to their job. Along with gasoline price variables, we also control for unemployment rate, median housing price, and temporal trend.

We run three sets of OLS regression models for each of the two response variables. There are 28 (7 × 2 × 2) models in the first set; we examine the individual effects of each of the seven gasoline price variables on the response variables with and without controls. The results of the first set of models reveal whether any of the seven price variables has an effect on residential location choice, and if so, how strong it is.

There are 16 (8 × 2) models in the second set. We examine the accumulative effects of gasoline prices and their changes on residential location with and without controls. For each of the two response variables, Model 1 looks at current prices; Model 2 looks at both current prices and change in prices at a one-year lag; Model 3 looks at current prices, change in prices at a one-year lag, and change in prices at a two-year lag; and Model 4 is like Model 3 but also includes change in prices at a three-year lag. Models 5 through 8 correspond to Models 1 through 4 except that the former include control variables.

There are 16 (8 × 2) models in the third set. We examine the accumulative effects of gasoline prices and their moving averages on residential location with and without controls. For each of the two response variables, Model 9 looks at current prices; Model 10 looks at both current prices and moving average in prices at a one-year lag; Model 11 looks at current prices, moving average in prices at a one-year lag, and moving average in prices at a two-year lag; and Model 12 is like Model 11 but also includes moving average in prices at a three-year lag. Models 13 through 16 correspond to Models 9 through 12 except that the former include control variables.

Gasoline Price Effects on Residential Location

Gasoline Price Effects on Leaving Previous Residence to Be Closer to Work/School

We first examine the effects of each of the seven gasoline price variables individually on movers who relocated to be closer to work/school, with and without controls. The seven gasoline price variables are price at current time; changes in prices at a one-year lag, a two-year lag, and a three-year lag; and moving averages in prices at a one-year lag, a two-year lag, and a three-year lag. The results are presented in the two left columns of Table 3. Gasoline prices have statistically significant ($p \leq 0.05$) effects on the decision to move closer to work/school based on three measures: current gasoline price, the change in gas prices at a two-year lag, and the change in gas prices at a three-year lag. Each percentage increase in current gasoline price is associated with a 1.71 percentage increase in movers relocating closer to work/school after controlling for unemployment rate, median housing price, and temporal trend. Each percentage increase in the change of gasoline prices at a two-year lag is associated with a 1.57 percentage increase in movers relocating closer to work/school with controls. Each percentage increase in the change of gasoline prices at a three-year lag is associated with a 1.55 percentage increase in movers relocating closer to work/school with controls. None of the moving average measures of gasoline prices have statistically significant effects on moving closer to work/school.

We next examine the accumulative effects of gasoline prices and their changes on movers who relocate to be closer to work/school, with and without controls in eight models. The results are presented in the first half of Table 4 and show that gasoline price at current time has significant and positive effects on those movers except in Model 7 (with the change of gas prices at a two-year lag and control variables) and Model 8 (with the change of gas prices and a three-year lag and control variables). Each percentage increase in current gasoline price is associated with a 1.71 to 2.22 percentage increase in movers relocating closer to work/school. Although the changes in gasoline prices at two-year and three-year lags are significant in explaining why movers choose to relocate closer to work/school individually in the models presented in Table 3, they become insignificant when considered along with current gasoline prices. This suggests that current gasoline prices are more influential than lagged prices in explaining why those movers relocated to be closer to work/school.

We further examine the accumulative effects of gasoline prices and their moving averages on moving closer to work/school, with and without controls. The results are presented in the second half of Table 4. The results show that gasoline price at current time has significant and positive effects on movers relocating closer to work/school in all eight models, regardless of whether the model includes control variables and regardless of whether the model includes controls for moving averages in gasoline prices. Each percentage increase in current gasoline price is associated with a 1.71 to 2.21 percentage increase in movers relocating closer to work/school.

Gasoline Price Effects on Selecting Current Residence to Be Convenient to Job

We model the effects of gasoline prices on movers who relocate to a residence convenient to their job in the same way we did for those who moved to be closer to work/school. The individual effects of gasoline price variables on the decision to relocate convenient to one's job are shown in the last two columns of Table 3. Most of the gasoline price measures have positive effects on moving to a residence convenient to job. However, none of the effects are statistically significant ($p \leq 0.05$).

We further examine the accumulative effects of gasoline prices, changes, and moving averages on moving to a location convenient to a job. The results are presented in Table 5.

Table 3. Individual Effects of Current Gasoline Prices, Changes (Δ), and Moving Averages (MA).

	Closer to Work/School		Convenient to Job	
	Without Controls	With Controls	Without Controls	With Controls
Gasoline prices, current time	1.960**	1.714**	0.820	0.054
	(0.218)	(0.228)	(0.207)	(0.300)
Gasoline prices, Δ 12-month lag	1.181	1.028	0.232	–0.343
	(0.181)	(0.202)	(0.198)	(0.301)
Gasoline prices, Δ 24-month lag	1.608*	1.566*	0.486	–0.170
	(0.197)	(0.218)	(0.200)	(0.300)
Gasoline prices, Δ 36-month lag	1.491*	1.546*	0.671	–0.053
	(0.197)	(0.215)	(0.203)	(0.300)
Gasoline prices, MA 12-month lag	1.580^{+}	1.209	1.040	0.357
	(0.187)	(0.203)	(0.206)	(0.301)
Gasoline prices, MA 24-month lag	0.624	0.219	1.365	0.988
	(0.170)	(0.193)	(0.209)	(0.306)
Gasoline prices, MA 36-month lag	0.237	–0.506	0.496	0.333
	(0.168)	(0.193)	(0.199)	(0.300)

Note: This table summarizes the results of 28 ordinary least squares regression models. Only the coefficients for gasoline prices are presented. R^2 statistic for each model is presented in parentheses. Control variables include unemployment rate and median housing price. Time is considered in all models.
*$p \le 0.05$; **$p \le 0.01$; ***$p \le 0.001$.

Similar to the results shown in Table 3, none of the gasoline price measures have statistically significant effects on moving to a residence convenient to a job. There are three possible reasons for this finding. First, moving convenient to a job is only an approximation of residential relocation in the context of gasoline price changes, as discussed in the Data section; moving closer to work/school is a better measure of residential relocation. Second, the variable "time," which measures the temporal trend, has positive and statistically significant effects on choosing a residence convenient to a job in most of the models. The temporal trend variable might capture more variation in the response variable than gasoline price variables do; in other words, the response variable is better explained by the temporal trend than by gasoline price measures. This is in contrast to the results of the first response variable, moving closer to work/school, for which the current gasoline price variable has a stronger explanatory power than the temporal trend does. Third, the small number of observations (n = 156) typically "penalizes" the statistical significance of coefficients.

Conclusion and Discussion

Summary

Recent volatility in gasoline prices has resulted in complex social and spatial implications for individuals, the public, and transportation and land use planners and decision makers. Existing literature has examined the impacts of gasoline prices on traffic safety (e.g., Chi et al. 2011), public transportation (e.g., Lane 2010), and commuting behaviors (Goodwin, Dargay, and Hanly 2004; Graham and Glaister 2004). Although gasoline prices alone are too small of a factor to *make* people move, higher gasoline prices *affect* decisions to move to locations closer to workplaces to reduce travel costs. However, this possible linkage has not yet been investigated. This preliminary study fills the gap in the literature by investigating the effects of gasoline prices on residential location using data from the 1996–2008 American Housing Survey. The results suggest that higher gasoline prices lead to higher proportions of movers who relocate closer to work/school. Relocating closer to work/school is one mechanism by which movers respond to increased travel costs caused by higher gasoline prices.

Policy Implications

The preliminary findings have important implications for addressing the impacts of gasoline price changes on urban form and land use planning. First, higher gasoline prices are associated with high-density development. All else being equal, gasoline price increases lead to more people moving closer to workplaces. If gasoline prices show an uptrend over a long term, we would expect a trend of residential relocation to places where jobs are—cities and suburban areas that have experienced employment growth in the recent past are likely to be those places. Consequently, the long-term decentralization process and low-density sprawl development might reverse and become a centralization process and high-density development.

Second, the impacts of gasoline price changes on land use planning could be enhanced by the public transportation infrastructure and containment policy. In cities and suburban areas where public transportation is available, an increase in gasoline prices could cause some commuters to switch from personal vehicle use to public transportation (Currie and

Table 4. Accumulative Effects of Gasoline Prices, Changes (Δ), and Moving Averages (MA) on Movers Selecting Locations Closer to Work/School.

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
$ gasoline, current time	1.960**	2.120**	1.884*	2.224*	1.714**	1.828*	1.488	1.705
$ gasoline, Δ 12-month lag		–0.309	–0.564	–0.586		–0.217	–0.525	–0.542
$ gasoline, Δ 24-month lag			0.579	0.831			0.782	0.872
$ gasoline, Δ 36-month lag				–0.696				–0.373
Unemployment rate					–0.388	–0.391	–0.366	–0.379
Median housing price					–2.05E–5	–1.98E–5	–2.33E–5	–2.08E–5
Time	0.006	0.005	0.006	0.006	0.020	0.019	0.021	0.020
Constant	4.855***	4.647***	4.981***	4.472**	10.809*	10.554*	11.553*	10.845*
R^2	0.218	0.219	0.220	0.222	0.228	0.228	0.231	0.232
	Model 9	**Model 10**	**Model 11**	**Model 12**	**Model 13**	**Model 14**	**Model 15**	**Model 16**
$ gasoline, current time	1.960**	2.186*	2.087*	2.147*	1.714**	2.068*	1.959*	2.205*
$ gasoline, MA 12-month lag		–0.421	0.158	0.177		–0.669	0.021	–0.072
$ gasoline, MA 24-month lag			–0.754	–0.159			–0.944	0.208
$ gasoline, MA 36-month lag				–1.010				–2.286
Unemployment rate					–0.388	–0.378	–0.370	–0.267
Median housing price					–2.05E–5	–2.30E–5	–2.48E–5	–3.97E–5
Time	0.006	0.008	0.009	0.010	0.020	0.024	0.026	0.035*
Constant	4.855***	5.090***	5.485***	5.975***	10.809*	11.608*	12.435**	16.127**
R^2	0.218	0.219	0.220	0.223	0.228	0.230	0.232	0.242

Note: n = 156.
*$p \le 0.05$; **$p \le 0.01$; ***$p \le 0.001$.

Phung 2008; Lane 2010). The effect is stronger in high-density development areas (Lee and Lee 2013).

Third, gasoline prices interact with land use policies in affecting migration decision-making. Gasoline price increases have a stronger effect on public transportation ridership in communities that implemented "smart growth" land use strategies than those without smart growth policies (Lee and Lee 2013). The transportation costs for residents living in those smart-growth communities are less affected by gasoline price increases than those in non-smart-growth communities; therefore, residents in smart-growth communities are less motivated to move when gasoline prices increase. Smart-growth communities are more resilient to gasoline price changes than those without smart growth land use planning or mixed land use development.

Limitations and Future Research

Although the contribution of this preliminary study is clear, it has a major limitation—this study is conducted at the national level only and does not consider individual characteristics. Data analysis at the individual level would produce more insights into the effects of gasoline price changes on residential location choice because reasons for moving differ by individual characteristics such as age, gender, race and ethnicity, labor force status, marital status, income, educational level, and homeownership. That said, conducting the analysis at aggregated levels provides an important and necessary understanding of the relationship between gasoline prices and residential location as that would allow the examination of the aggregated-level characteristics such as community characteristics, built environment, natural environment, and transportation accessibilities that are also important determinants of residential location choice. Therefore, adapting a systematic examination of the individual and aggregated-level characteristics will provide further insights into how gasoline prices and residential location are associated. Below we provide four possible aspects of future research.

First, gasoline price effects on residential location might differ by age, gender, race, household types, labor force status, and education levels. The sociological and urban planning literature emphasizes that the pattern of residential relocation varies by these demographic characteristics (e.g., Allen 2011; Clark and Onaka 1983; Guhathakurta 1999; Lee 1966; Shuttleworth and Gould 2010; Weinberg 1979; Zhang 2010). More recent research (e.g., Ihrke 2014) also found that the reason for moving varies by these demographic characteristics. Investigating gasoline price effects on residential location by age, gender, race, household type, labor force status, and education level would provide insights on the possible demographic variations of those price effects.

Second, gasoline price effects on residential location might differ between renters and owners. Because it is easier for renters to relocate than for owners to, gasoline prices might have immediate effects on the residential relocation of renters but intermediate or long-term effects on that of owners. It would be useful to partition the data into renters

Table 5. Accumulative Effects of Gasoline Prices, Changes (Δ), and Moving Averages (MA) on Movers Choosing Residence Convenient to Job.

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
$ gasoline, current time	0.820	1.101	1.109	1.069	0.054	0.363	0.439	0.554
$ gasoline, Δ 12-month lag		–0.541	–0.557	–0.556		–0.591	–0.522	–0.531
$ gasoline, Δ 24-month lag			0.036	0.023			–0.174	–0.126
$ gasoline, Δ 36-month lag				0.036				–0.199
Unemployment rate					–1.50***	–1.51***	–1.52***	–1.52***
Median housing price					–3.29E–5	–3.11E–5	–3.03E–5	–2.90E–5
Time	0.022*	0.020*	0.020*	0.020*	0.020***	0.048***	0.047***	0.047**
Constant	17.76***	17.31***	17.42***	17.44***	31.90***	31.20***	30.98***	30.60***
R^2	0.207	0.208	0.208	0.208	0.300	0.302	0.302	0.302
	Model 9	**Model 10**	**Model 11**	**Model 12**	**Model 13**	**Model 14**	**Model 15**	**Model 16**
$ gasoline, current time	0.820	0.515	0.684	0.752	0.054	–0.260	–0.102	–0.013
$ gasoline, MA 12-month lag		0.569	–0.431	–0.410		0.594	–0.408	–0.441
$ gasoline, MA 24-month lag			1.304	1.978			1.369	1.785
$ gasoline, MA 36-month lag				–1.143				–0.827
Unemployment rate					–1.50***	–1.51***	–1.52***	–1.48***
Median housing price					–3.29E–5	–3.07E–5	–2.80E–5	–3.34E–5
Time	0.022*	0.019	0.018	0.018	0.020***	0.047***	0.044**	0.048**
Constant	17.76***	17.44***	16.76***	17.31***	31.90***	31.19***	29.99***	31.33***
R^2	0.207	0.208	0.213	0.216	0.300	0.301	0.307	0.308

Note: n = 156.
*$p \leq 0.05$; **$p \leq 0.01$; ***$p \leq 0.001$.

and owners, and possibly also those changing from renters to owners and from owners to renters, and investigate gasoline price effects on their relocation separately.

Third, examining the relationship between gasoline prices and residential location in metropolitan and nonmetropolitan areas separately might provide further insights into the mechanism through which gasoline prices affect residential location (Shuttleworth and Gould 2010). Metropolitan areas have higher levels of income to buffer higher gasoline prices and have alternative transportation modes—public transportation—for residents to switch to in response to gasoline price increases. In contrast, nonmetropolitan areas have lower levels of income and have no public transportation to respond to gasoline price increases. The effects that gasoline prices have on residential location might be stronger in nonmetropolitan areas than in metropolitan areas. In addition, the association between gasoline prices and residential location might exhibit regional difference, which should be examined in future research as well.

Fourth, gasoline price effects on residential location might also be investigated within time geography theory (Hägerstrand 1970). Time geography theory can provide explanations for the effects of gasoline price changes on residential location because gasoline prices can be considered a capability constraint. We expect that as gasoline prices increase—and the capability constraint becomes stronger—people will move closer to their workplaces in order to reduce gasoline expenditures, leading to shorter space-time paths. Increased gasoline prices could also induce workers, especially low- and medium-income automobile commuters who live far from their workplaces, to relocate closer to their workplaces (shorter space-time paths) and may encourage low-wage, younger, and part-time workers to find jobs nearer their residences (shorter space-time paths).

Residential location choice is affected by both individual characteristics and the environment where the individual lives. Investigating the multiple aspects of residential location choice, including the four discussed above, could provide a systematic understanding of residential location choice in association with gasoline price changes. This might be best achieved within a multilevel framework as that allows the simultaneous consideration of a number of driving factors that are available at the individual level and several geographic scales (Chi and Voss 2005).

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