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# Join the Club: Club Goods, Residential Development, and Transportation

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**Abstract:** A good and sustainable city requires compatibility between the various functions and services that it provides its residents. This study examined the relations between the development of new residential neighborhoods and transportation infrastructure by applying Tiebout's model of club goods. Thus, we introduced the spatial dimension into the theory of club goods by referring to neighborhoods as clubs and their residents as the club's members, who make location decisions. Specifically, we explored how residents behave spatially in response to the problematic transportation infrastructure of the neighborhoods. That is, to consider the socioeconomic implications of inadequate transportation infrastructure, we used data from newly developed neighborhoods in Israel to examine the extent to which an increase in traffic congestion can reduce a neighborhood's size. Our findings show a negative correlation between increases in travel time and the number of housing transactions undertaken in a given neighborhood, thus confirming Tiebout's assumption that people vote with their feet: When traffic congestion increases, residents prefer to leave the neighborhood and move, in all likelihood, to a place with less congestion. The paper also discusses the results with respect to the social consequences of these trends and warns against the expected socioeconomic consequences, namely that those who can afford to do so will leave in favor of a club with better conditions. The key lessons derived from this study of the Israeli experience are considered relevant to many other countries experiencing similar situations.

**Keywords:** residential development; transportation infrastructure; club goods; Tiebout; Israel



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## 1. Introduction

Cities have always embodied a wide range of human functions (such as residence, transportation, employment, commerce, and social life) whose relative importance changes over time, placing new demands on the built environment [1,2]. Within the cities, the development of new residential neighborhoods is a complex task requiring the provision of public facilities and amenities in addition to housing units. Such services include, for example, education, health, water, and garbage disposal.

Transportation infrastructure is one of the key services affecting the environment, public health, and the quality of life [3–9]. Adequate transportation infrastructure leads to a wide variety of positive outcomes such as reducing dependence on private cars, lowering the level of air pollution, reducing traffic accidents and saving human lives, reducing travel times, and in turn, increasing the work time, productivity, and other positive elements. It also affects the ease of spatial movement within new neighborhoods and the accessibility of employment and shopping centers. On the other hand, inadequate transportation infrastructure coupled with residential development may increase dependence on private cars, increase air pollution, and create traffic congestion, which may lead to loss of work time and family time. Therefore, compatibility between all the services a city provides to its residents, especially between transportation infrastructure and residential development, is a necessary condition for a good, just, and sustainable city [8].

For the most part, the building of transportation infrastructure takes longer than that of new housing, primarily because decisions regarding the allocation and amount of funds necessary to design and construct transportation facilities are made by agencies beyond the control of neighborhood developers. Consequently, the development of new residential areas often creates incompatibilities between the rate of development, occupancy of the residential units, and the readiness of the transportation infrastructure. This gap may lead to unwanted social and environmental outcomes such as severe traffic congestion in the short run and uncoordinated urban sprawl in the longer run, as residents respond by migrating to more favorable locations [10,11].

To avoid such outcomes, and as part of the increase in environmental awareness and the desire to create sustainable cities, many cities and states worldwide have encouraged, for the last two decades, a policy of integrated housing and transportation planning [11]. Such attempts have been observed in Copenhagen, Denmark [11]; Groningen, the Netherlands [12]; Edmonton, Canada [13]; Atlanta and Oregon, USA [14,15], and elsewhere. The purpose of such policies is to reduce car traffic while maintaining a good level of accessibility to places of employment. This has often resulted in compact and mixed urban development with respect to the construction of new satellite towns [11]. However, by and large, the planning of new neighborhoods that include the public services needed to sustain healthy development, even when framed by integrated policies, lacks the planning, and consequently, the construction, of appropriate transportation infrastructure.

To what extent does the imbalance between new neighborhoods and the requisite transportation infrastructure affect the well-being of the occupants of these neighborhoods? How does it affect residential location decisions? What are the long-term socioeconomic consequences of this incompatibility? This study seeks to answer these questions both theoretically and empirically. We used club goods as a theoretical framework in which the new neighborhood represents the club and the transportation infrastructure represents a public good.

As a case study, we chose Israel, a country that has undergone rapid and intensive new development of residential neighborhoods accompanied by inadequate development of the necessary transportation infrastructure. The rapid development of these neighborhoods occurred, especially following the social protest in the summer of 2011 against the cost of living in general and housing prices in particular. Following the protest, the issue of housing rose to the forefront of the public and political debate, and the government made many decisions aimed at increasing the stock of apartment units in order to lower their price [16–23].

We focused on the behavior of residents in 39 Israeli neighborhoods established since 2010 and are currently facing acute commuter traffic congestion caused by underdeveloped transportation infrastructure. The behavior of these neighborhoods' residents was subsequently examined empirically within the framework of Tiebout's (1956) [24] model of club goods. Unlike Tiebout, however, we also considered the external impact of bringing more people into a new neighborhood without proper infrastructure and examined its effect on the behavior of the new residents and their decisions regarding moving or staying in the neighborhood. We used a 2SLS statistical model to test the assumption that increasing the density affects people's decisions to stay in a neighborhood.

The rest of this paper is organized as follows. Following the introduction, Section 2 presents the theoretical framework for the analysis, focusing on club goods and Tiebout's (1956) [25] model. Section 3 contains a succinct description of current Israeli housing policy regarding the establishment of new residential neighborhoods. Section 4 presents the research methodology, along with our Israeli dataset. Section 5 presents the results of the statistical analysis and our main findings. The conclusions are discussed in Section 6.

Our findings showed a negative correlation between an increase in travel time and the number of housing transactions undertaken in a given neighborhood. The number of housing transactions was chosen because this variable may be viewed as instrumentalizing Tiebout's assumption (1956) that people vote with their feet: When traffic congestion increases, residents prefer to leave the neighborhood and move, in all likelihood, to a place with greater accessibility to transportation. That is, whereas the literature on club goods deals primarily with positive incentives for locational decisions, the current study takes an alternative stance by investigating the negative incentives—traffic congestion and inadequate transportation infrastructure—for the same decisions.

The study discusses the long-term socioeconomic consequences of these trends and points to the worrying social consequences that may worsen if the trend of populating residential projects without providing adequate transportation (and other) infrastructure continues [25–27]. The key lessons derived from this study of the Israeli experience are considered relevant to many other countries experiencing similar exigencies. This is due to the global affordable-housing crisis and the desire of many governments to lower housing prices and meet demand by increasing the supply of housing and the construction of new residential neighborhoods.

The study does not deal with transportation models or with the types of transportation infrastructure (for private or public transportation). These issues are important, but were beyond the scope of the current study. Moreover, as already mentioned, the increase in traffic congestion also has significant environmental consequences that directly affect the quality of life of the residents and public health, but these issues were also beyond the scope of this study.

## 2. Club Goods Theory and Residential Neighborhoods

Within the theory of public goods, club goods form a distinct category characterized by output excludable from others' consumption and non-rivalries (assuming capacity is nonbinding to the servicing of all users). However, as with other types of public goods, the marginal costs of servicing other users are zero [28]. Consumption of the club's products relies on a voluntary act (that is, joining the club), and the production cost of the service is funded by the user's fee. In this case, the purchase price of the housing unit constitutes a kind of joining the club, regardless of the household's level of consumption. Given these economic attributes of public goods, club goods are a convenient mechanism for examining the characteristics and preferences of a new neighborhood's residents.

In terms of our subject, individuals who decide to purchase a residential unit in a newly developed area voluntarily join a "club", whose members are the owners of the other new units and who consume a set of services including transportation infrastructure. Whereas some (e.g., parents of school-age children) may consume more education services, others may prefer to consume more open spaces, income, and other household socio-economic and demographic characteristics. The club's membership fees thus consist of a residential unit's purchase price, which normally also covers the costs of that unit's construction, and the local government's supply of public services such as education, health, and transportation.

However, what would be the response of residents (members of this "club") once they realize that a key public service—transportation—is largely unavailable or supplied at a level insufficient to accommodate the demand? Tiebout (1956) [24] provides an interesting approach to answering this question. The congregation of residents with similar socioeconomic and cultural attributes in discernable neighborhoods in metropolitan areas is a well-documented phenomenon. The explanations of this phenomenon include sociological, political, and economic analyses. The last are grounded mainly in public goods theory, where the additional costs of adding one more resident to a neighborhood is zero (or close to it), given the range of outputs provided by the political or bureaucratic entity in charge. In 1956, Tiebout published his seminal paper modeling how homogenous neighborhoods are formed in the framework of club goods. The model likens neighborhoods to clubs whose members pay annual dues (e.g., property tax) and receive a bundle of services (e.g., schools, and open spaces) at zero additional cost.

Tiebout's major contribution to the economics of club goods was to introduce the spatial dimension into his model, which shows that people may switch between club goods if unsatisfied with the kind, amount, and quality of the services they receive. In the context of new neighborhoods, this implies that residents can "vote with their feet", that is, leave locations with poor transportation services for others that do meet their expectations regarding mobility and accessibility. As we have explained, deciding to live in a particular municipality (or, in this case, a specific neighborhood) constitutes "joining a club". The decision to purchase or rent a residence can thus be considered a "package deal", meaning that people join clubs (move to neighborhoods) that meet their expectations regarding the level of service delivery (for example, transportation) [29–31].

Given the premises in the Tiebout model, an optimal club good in the present instance can be defined as a "bundle of goods and services" that a household receives upon purchasing (or renting) a residence. Given the household's socioeconomic characteristics (e.g., size, income, type, and place of employment), this bundle is meant to maximize household welfare. In our case, purchasing a given residential unit in a specific neighborhood that provides a particular set of services implies that the household has chosen what it believes to be, at the time of purchase, an efficient club. However, the level of accessibility of that location is largely unknown prior to purchasing the apartment or actually moving to the neighborhood (joining the club). If these transportation needs cannot be met because of, for example, the under-supply of infrastructure, the household is unable to maximize the utility gained by joining the club, making the good nonoptimal, which implies a loss of welfare from joining the club.

As a result of membership in such a nonoptimal club and palpable recognition of the ensuing loss of welfare, the household becomes predisposed to vote with its feet, that is, relocate to a different neighborhood, one that provides greater accessibility to the respective good and thereby enhancing the household's relative welfare. A key outcome of this spatial re-allocation process is the emergence of more socioeconomically uniform neighborhoods. According to Tiebout's assumption, those who can afford to do so will leave the neighborhood (club) and improve their living conditions, while those who cannot afford to do so will be forced to stay in the neighborhood, despite the unsatisfactory transportation conditions. That is, those who remain in the neighborhood are the less affluent populations, and the neighborhood will gradually become more homogeneous at a lower socioeconomic level.

Tiebout's model is based on several premises including the absence of major barriers to spatial mobility (e.g., zoning), the costlessness of the information about the level and quality of the bundle of services provided by each neighborhood (excluding information on accessibility, available only post-relocation), and the probable short-run stability of government policies.

Over the years, several studies have examined Tiebout's model in various municipalities, under different conditions and at different scales. McGuire (1974) [32] showed that Tieboutian clubs create incentives to segregate into homogeneous and isolated locations, on the basis of income and consumption preferences. Heikkila (1996) [33] examined more than 100 local governments in Los Angeles County in California; using factor analysis, he confirmed that residents tended to flock to communities based on their similar preferences for the services offered, thus establishing spatially sorted municipal clubs with homogeneous members. Blanco, Martin, and Vazquez (2016) [34], who treated Spain's provincial regions as if they were Tiebout clubs, examined whether regional characteristics affected the likelihood that any given province would be found to belong to a specific convergence club.

Other studies have applied the Tiebout club goods model at the neighborhood level, given that housing units tend to be marketed not only as individual homes, but also as club goods or contractual tie-ins to the neighborhood [35,36]. Moreover, the congregation of residents with similar socioeconomic and cultural attributes in discernable neighborhoods in metropolitan areas is a well-documented phenomenon. The array of explanations given for this phenomenon includes sociological, political, and economic analyses, with the last grounded mainly in public goods theory. These studies have usually focused on private neighborhoods, gated communities, homeowners' associations (HOAs), or common interest housing developments (CIDs). In these cases, individual owners may profit from stable home values because housing prices act as a filter, allowing only families enjoying a certain socioeconomic status to enter the neighborhood. Prices thus ensure that the neighborhood's prestigious image is preserved, as is the economic value of its homes [35–40].

In practice, when households start occupying units, the transportation infrastructure (other than that for private cars) is commonly missing; however, the expectation of its availability in the near future is cultivated by the developers or local authorities. If these expectations are not met, the club becomes suboptimal and the household can choose to respond by relocating to another neighborhood. Similarly, if it is known a priori that transportation will be supplied at an adequate level only in the very long-term, the household may decide to purchase elsewhere, either in a less-favorable location or for a higher price where transportation is immediately available. In this case, the decision to do so does not represent utility maximization relative to the original case. In either instance, household relocation behavior (voting with one's feet) is the mechanism used when provision of the club good's major component, in this case, transportation infrastructure, turns out to be suboptimal. These changes may have significant social consequences because when residents are dissatisfied with the club's performance, only those who can afford to move to a site where conditions are more attractive, that is, the presence of socioeconomically stronger populations, can actually do so. Thus, over time, a neighborhood lacking good accessibility (that is, transportation infrastructure) may be emptied of its more-affluent population and become occupied solely by a homogeneous, socioeconomically weakened population.

Households follow a learning curve in recognizing the consequences for daily commuting of the lack of adequate public transportation. Furthermore, travel conditions may deteriorate over time as more inhabitants settle in the newly developed neighborhood. Therefore, when applying the empirical model with respect to transportation services, we allow for a time lag between travel conditions and a household's decision regarding spatial relocation, implemented by buying, selling, or renting a new unit elsewhere.

The compatibility between the construction of new housing units and transportation infrastructure creation can be used as a measure of the club's efficiency. A total lack of compatibility between these components is thus regarded as a clear violation of club efficiency. Inefficient or suboptimal clubs subsequently exhibit long-term resource misallocations due to the ensuing resident relocation behavior. That is, misallocations cause the occupied and empty residential units to be higher or lower than could be anticipated if the clubs had been economically optimal, that is, if they provided housing and transportation at the necessary, coordinated levels. A key objective of this study is, therefore, to examine the socioeconomic consequences of this incompatibility.

## 3. Residential Development in Israel in the New Millennium

The development of new neighborhoods is subject to federal, regional, and local conditions, policies, and interests, which often serve as constraints on the process. In Israel, as in other developed countries, such constraints also severely impact planning. It was beyond the scope of this paper to thoroughly review these issues, so only a brief description of the Israeli case is given as background [41–44].

Israel provides an interesting case for examining national residential development because it is an advanced-economy democracy that has always had a high degree of centralized policymaking, especially regarding spatial and land use (planning) policy [41] (pp. 47–58). Israel is also a small country (21,500 sq km) that is densely populated (395 per sq km, ranking 29th of 245 countries), with a higher population growth rate of 2% compared to the average 0.7% in developed-economy societies [45–47].

Studies conducted since the early 1990s show that about 30 new neighborhoods have been established on the margins of existing cities [48,49]. These trends have intensified greatly since the mid-2000s [50], with government housing policy at the time of writing encouraging this pattern and perhaps intensifying it, as will be explained [2,21,51].

Since 2007, the general cost of living has increased greatly in Israel, especially with regard to housing. According to the State Comptroller's Report (2015) [52], between 2007 and 2015, the cost of both new and secondhand housing in Israel rose 70%. This upward spiral was one of the factors motivating the largest social protest in Israel's history, in the summer of 2011 [18–20,22,23,53,54]. Following the 2011 protest, the Israeli government decided to increase the supply of housing units and reduce their price by means of massive residential development programs [21,55]. To speed up the process, the government instructed planning institutions not to wait for the completion of the required transportation infrastructure before starting construction, contrary to the practice in other countries. A comment by the chair of the National Housing Committee concisely captures the government's approach: "Take a sleeping bag and sleep on the floor; I don't care. I will not wait for roads to build apartments" [56]. Consequently, dozens of new neighborhoods containing hundreds of thousands of housing units are being built and occupied, many in the country's center [50,57] (nine of the 22 Umbrella Agreements (Heskemei Gag) with municipalities for the construction of new housing are in the Central District [57]) and often using existing transportation infrastructure. Many of those neighborhoods, built in the Central District of the country, are already very crowded, even before most of the housing units have been occupied [50,58]. This policy has created significant traffic overload, to the point where the issue is now at the forefront of public debate [59–61].

## 4. The Database and Research Methodology

### *4.1. The Database*

The current study examined the incompatibility between the development of residential neighborhoods and transportation infrastructure. The methodology we designed for this purpose was based on two unique databases: one consisting of real estate transactions and the other consisting of transportation congestion. In the initial phase, in order to select the relevant neighborhood authorities, we used data from Israel's Central Bureau of Statistics (CBS). We focused on the Central District because, according to data collected by the CBS, most new residential development and internal migration in the last two decades have taken place in this region, as presented in Figure 1 [50,58].

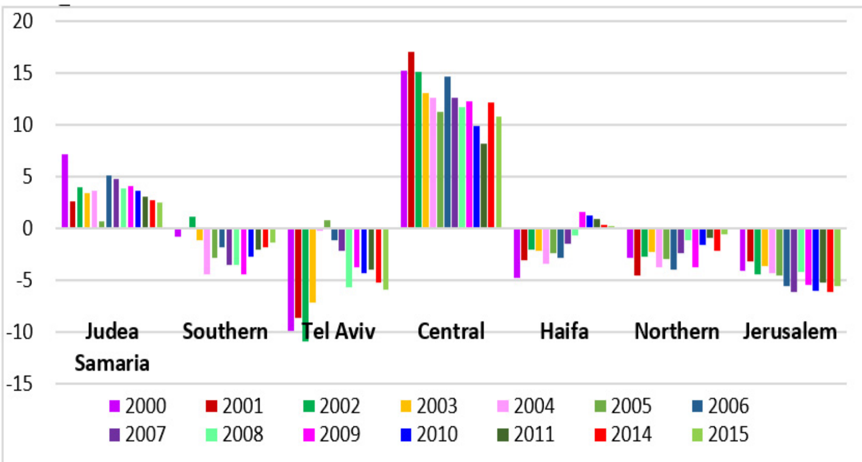


**Figure 1.** Israel's internal migration rate by district, 2000–2015-in thousands. Source: CBS, calculations by the authors. The Judea and Samaria District is internationally recognized as part of the Palestinian occupied territories, and not as part of the State of Israel.

The first set consists of new neighborhoods in local authorities in the Central District of Israel. We used the dataset developed by Points Location Intelligence Ltd. (henceforth Points), which combines social, economic, and demographic attributes of each neighborhood in the country. The Points dataset has several advantages over government data provided by the CBS. First, it is updated regularly, using statistical and socio-spatial analysis models, and is therefore more up to date (May 2020) than CBS data, which are based on the last census (2008). Second, Points integrates information obtained from the CBS with other sources of socioeconomic and demographic data including consumer data obtained from commercial companies, real estate prices, findings from various publications, and additional data collected by Points for its customers (see: Points Location Intelligence Ltd., Ramat Gan, Israel https://points.co.il/en/points-location-intelligence/, accessed on 12 October 2022).

We subsequently examined all of the housing transactions conducted in all the neighborhoods within the jurisdictions of these municipalities (a total of 211 neighborhoods) between 2011 and 2019. Of the original 211, we were able to identify 39 neighborhoods built from the ground up (Appendix A: Selected neighborhoods within the Central District municipalities), meaning that the transaction history we had observed in these neighborhoods was a very small number of transactions, followed by an increase in the number of transactions, followed by a decrease. We took this transaction history to imply that the residents had first populated the newly developed neighborhoods, then lived there for some time (no transactions). Once these residents had acquired adverse living experiences caused particularly by the inadequate transportation system, they were able to translate these constraints into the true costs of accessibility (in units of time and money) to carry out their daily activities. Following Tiebout's model, we attempted to estimate the residents' response to these conditions, accomplished by moving to "clubs" that were better in terms of the desired level of accessibility. To measure the variable of transactions, we examined all of the real estate transactions (buying, selling, and renting) in these neighborhoods between 2011 and 2019. With regard to real estate transactions, the Points dataset is based on the Israeli government's real estate database but optimized by Points.

The second dataset contained traffic data and was designed for this study by MATAT—Transportation Planning Center Ltd., Azur, Israel. The dataset contains the estimated changes by year (2016–2018) in traffic congestion at peak times to and from the selected neighborhoods. We conducted two types of measurements from each neighborhood to the nearest major employment area (in Tel Aviv). In November 2019, we performed another measurement of congestion using the Google Maps API. Thirty-five tracks were monitored during three time periods: (a) morning peak hours (07:00–09:00); (b) afternoon peak hours (16:00–19:00); and (c) daily average (06:00–22:00). This information was compiled by constant monitoring of cell phone locations using the Android operating system with Google traffic measurements. Approximately 84% of the country's smart cell phones were based on this operating system as of 2019.

The Central District's road network was coded for the year 2016; it includes 200 sections of single-, double-, and triple-lane roads covering 4300 km of roadway. To obtain data for previous years, given that no retroactive data were provided under the Google license, manipulation was performed using the continuously monitored travel time during 2016–2018 (The Ministry of Transportation activated its Google license in February 2016). Travel times from a number of interurban segments were collected in real-time. To account for changes in the variables underlying travel demand such as population size and travel times from a specific neighborhood to the nearest interchange leading to an interurban highway, travel-time data recorded under the conditions existing in 2019 were used to estimate the travel times for previous years. Finally, to neutralize the effect of holidays, we chose November as a representative month for the computations (no holidays are celebrated in Israel during that month).

### 4.2. Methodology

As explained above, according to Tiebout's model, the lack of compatibility between the residents' expectations and the actual level of public service provision in a neighborhood, in this case transportation, will result in the residents' voting with their feet, that is, the departure of the more-affluent population from the neighborhood and a decrease in demand for that neighborhood's housing. We therefore chose to explore how neighborhood size or, rather, the number of households (or housing units), is affected by significant traffic congestion. In other words, we examined the extent to which an increase in traffic congestion can reduce a neighborhood's size, a process with socioeconomic implications. For this purpose, we first observed long-term changes in real estate transactions and housing unit prices in the selected neighborhoods. Then, we used data regarding the estimated level of congestion by examining the daily commuter traffic from the newly built neighborhood to nearby central employment centers. This model is an iterative system in which changes in the number of a neighborhood's residents affect the congestion level, and that, in turn, affects the propensity of veteran households to stay or move out of the neighborhood and "join" a new club.

To account for this simultaneity, a 2SLS regression analysis was employed. This statistical technique is used in the analysis of structural equations that, in our case, takes into account the intervening variables such as housing prices, housing density, and the particular neighborhood's socioeconomic status, which affect the neighborhood size. 2SLS models usually used when the dependent variable's error terms are correlated with the independent variables. If we were to use simple OLS in the equation, we might have obtained biased and inconsistent estimates. The 2SLS approach is an extension of the structural equation modeling (SEM) used to estimate relationships between the measured variables and latent constructs and is an alternative to estimating the path coefficient.

An important caveat regarding the reasoning behind the above model is the assumption that the costs of relocation are negligible, that is, that households that decide to join a new "club" face spatial relocation costs that are insignificant relative to the anticipated net welfare gains. The model assumes that traffic conditions (that is, the transportation infrastructure) affect the long-term number of transactions (buying, selling, and renting) in a neighborhood, given the market prices of residential units. We estimated the following equations: The log-linear form accounts for differences in variable units such as the number of transactions (in thousands) and peak-period duration (in minutes).

$$(lnCount_{it}) = \beta_{0j} + \beta_1 lnPeak_{i,t-1} + \beta_{2j} lnPrice_{it} + \vec{\beta}_{3j} FE_{it} + \varepsilon_{it} \quad (1)$$

$$lnNhh_{it} = \beta_{0j} + \beta_{1j} lnCount_{it} + \beta_{2j} lnDenshh_{it} + \varepsilon_{it} \quad (2)$$

In Equation (1), $lnCount_{it}$ is the number of transactions in neighborhood $i$ during period $t$. The variable $lnpeak_{i,t-1}$, on the right-hand side of (1), is a measure of traffic density in the morning or afternoon peaks or in the daily average period. Since we assumed a learning period during which new residents comprehend the effect of increasing traffic on their well-being, we used a one-year lagged traffic period ($t - 1$) effect on the number of transactions during year $t$ ($lnCount_{it}$). The variable, $lnPrice_{it}$ stands for the log of housing prices in the neighborhood in year $t$.

To examine the relationship between the variables (travel time and number of transactions in the neighborhood), one must control for the differences between neighborhoods and time. Neighborhoods differ from one another in a variety of characteristics such as location, density, types of properties, and degree of accessibility and proximity to employment areas. In addition, the time frame must be controlled to overcome changes that occur in a neighborhood over time such as planning and development or population trends. We therefore added to the equation a fixed effect for neighborhood and time (per year). $FE$ and $FE$ are thus vectors of time and neighborhood fixed effects, respectively.

In Equation (2), $lnNhh_{it}$ is the log of the number of households in the neighborhood, used as a proxy for neighborhood size. On the right-hand side of Equation (2), we have $lnCount_{it}$, the log of the number of housing transactions in the neighborhood, and $lnDenshh_{it}$, denoting neighborhood density.

Using logs, or summarizing changes in terms of continuous compounding, has a number of advantages over looking at simple changes. Logarithms are often a much more useful way to look at economic data and are also convenient for describing relations between economic variables. Logs can directly show how a 1% change in one variable affects the dependent variable.

*4.3. Challenges and Obstacles*

Of the 211 neighborhoods that are within the municipal boundaries of the cities in the Central District, we were able to locate 39 neighborhoods that were established from the ground up (according to the number of transactions in the neighborhood). Ideally, we would have been happy to perform an analysis with a larger number of neighborhoods and transactions. Because of the limited number of cases, we cannot claim to show a causal effect between the traffic conditions (that is, the transportation infrastructure) and the long-term number of transactions (buying, selling, and renting) in a neighborhood. This would also require a natural experiment relating to each of the neighborhoods as future research.

In relation to the traffic data, we encountered a significant lack of available data. We managed to overcome the shortage by contacting a private company (MATAT—Transportation Planning Center Ltd.), which performed a measurement for us, and by using transportation data they acquired from the Ministry of Transportation over the years. Travel times were measured from the central intersections adjacent to each of the selected neighborhoods and not from the exits from the neighborhoods themselves. Thus, the study did not include the severe traffic congestion at some neighborhood exits. This is because the traffic network that was codified in 2016 includes only intercity roads and not local roads.

Another limitation involves traffic data, which were limited to a maximum of four years in each neighborhood (from 2016 to 2020 only). An examination of changes in the neighborhood characteristics and infrastructure would benefit greatly from longitudinal data over a longer period. Such data would allow for a better analysis of the Tiebout model. Nevertheless, the in-depth analysis of the 39 selected neighborhoods provides interesting findings and a possible explanation of the impact of incompatibility between transportation and residential development, as we will show later.

## 5. Estimation and Key Results

Tables 1 and 2 contain the results of the 2SLS model estimation presented in Equations (1) and (2) (Appendix B: model regression outputs). The model was estimated for the afternoon peak (column 1), the morning peak (column 2), and the daily average (column 3). The model examines the effect of changes in traffic loads on the neighborhood size by means of the number of real estate transactions taking place in the neighborhood. The 2SLS model we ran showed a negative correlation between the number of transactions and peak period travel time; that is, an improvement in traffic conditions increases the number of housing transactions concluded in the neighborhood. A 1% increase in afternoon peak travel time (column 1) was correlated to a 4.48% decrease in the number of transactions observed a year later. The results also showed a positive correlation between housing prices and the number of housing transactions. That is, a 1% increase in housing prices was correlated with a 2.03% increase in the number of housing transactions in the same year (significant at 1% and 5%, respectively).

**Table 1.** Outcomes of the estimation of Equation (1) using 2SLS.

| Dependent Variable: Count (No. of Transactions) | (1) Afternoon Peak | (2) Morning Peak | (3) Daily Average |
|---|---|---|---|
| $lnPeak_{i,t-1}$ | −4.48 *** (0.88) | −4.12 *** (1.27) | −6.00 ** (1.85) |
| *InPrice* | 2.03 *** (0.54) | 1.58 *** (0.48) | 2.12 *** (0.63) |
| *Constant* | −22.54 *** | −16.52 *** | −26.5 *** |
| $R^2$ | 0.71 | 0.75 | 0.80 |
| *N* | 72 | 106 | 72 |

Legend: ** indicates a significance level of 0.05; *** indicates a significance level of 0.01; t-statistics appear in brackets.

**Table 2.** Outcomes of the estimation of Equation (2) using 2SLS.

| Dependent Variable: HH (No. of Households) | (1) Afternoon Peak | (2) Morning Peak | (3) Daily Average |
|---|---|---|---|
| $L1.lnCount_{it}$ | 0.117 *** (0.045) | 0.125 *** (0.036) | 0.117 *** (0.045) |
| $lnDenshh_{it}$ | 0.425 *** (0.09) | 0.466 *** (0.07) | 0.425 *** (0.09) |
| *Constant* | 3.53 *** | 3.15 *** | 3.53 *** |
| $R^2$ | 0.38 | 0.37 | 0.38 |
| *N* | 72 | 106 | 72 |

Legend: *** indicates significance level of 0.01; t-statistics appear in brackets.

Equation (2) (Table 2) shows that the number of transactions was positively correlated with neighborhood size; that is, a 1% increase in the number of transactions was correlated with a 0.117% increase in neighborhood size (number of households in the neighborhood). The density of households was also positively correlated with the neighborhood size; that is, a 1% increase in household density was correlated with a 0.425% increase in neighborhood size. We conducted the same test with respect to the morning peak travel time (column 2, Tables 1 and 2). We found that an increase in morning peak travel time was negatively correlated with the number of transactions concluded that same year; that is, a 1% increase in travel time was correlated with a 4.12% decrease in the number of transactions in that year. In the same equation, we also found a positive correlation between housing prices and the number of transactions conducted in the same year.

We also found a positive correlation between the number of transactions and neighborhood size. A 1% increase in the number of transactions was positively correlated with a 0.125% increase in the neighborhood's size. The density of households in the neighborhood was also positively correlated with its size; that is, a 1% increase in household density was correlated with a 0.466% increase in the size of the neighborhood.

It can therefore be concluded that an increase in travel time was positively correlated with a decrease in the number of transactions concluded in the same year, which may lead to a decrease in neighborhood size. We also found a positive correlation between housing prices and the number of housing transactions concluded; that is, a 1% increase in prices was positively correlated with a 1.58% increase in the number of transactions.

We ran a third model examining the correlation between the average daily travel time (Table 1, column 3) and the number of transactions in the neighborhood, which we found to be strongly negative. An increase of 1% in the average daily travel time in a given year was negatively correlated with a decrease of 6% in the number of transactions concluded in the following year. Prices were also positively correlated with the number of transactions. An increase of 1% in the price level was associated with a 2.12% increase in the number of transactions. The rise in demand (or increase in the number of transactions) affected the prices positively.

In the second equation, we found a positive correlation between the transactions concluded and neighborhood size (Table 2). A 1% increase in the number of transactions in the neighborhood was positively correlated with a 0.117% increase in the size of the neighborhood. The density of households in the neighborhood was also positively correlated with its size; that is, a 1% increase in household density was positively correlated with a 0.425% increase in neighborhood size (number of households in the neighborhood).

It can be concluded that the three measurements we ran indicated a negative correlation between increased travel time (whether the morning peak, afternoon peak, or daily average) and the number of housing transactions concluded in the neighborhood. In the first stage, when traffic congestion increased, we also observed an increase in the number of housing transactions due to parallel buying and selling. However, in the following year, the neighborhood size, in terms of housing units, decreased because the number of transactions was correlated with neighborhood size.

To confirm the results of our analysis with the model we used, we performed an ANOVA test (Appendix C: ANOVA test outcomes). This test examined the contribution of each variable (travel times, neighborhood characteristics, and housing prices) to the explanation of the variance in the dependent variable (here, neighborhood size). We used a fixed effect for each neighborhood evidencing characteristics such as neighborhood age, socioeconomic level, and size.

We found that a combination of travel times (peak morning and peak afternoon) and neighborhood characteristics contributed about 80% to explaining the variance in neighborhood size (number of household units in the neighborhood). In addition, the contribution of each variable separately (neighborhood characteristics and travel time) was significant.

As for the other variables, the contribution of housing prices to the explanation of the variance in neighborhood size was not found to be significant. The interaction between neighborhood housing prices and afternoon peak travel time was found to be significant in explaining the variance in the number of housing transactions, although no similar effect was found regarding the morning peak travel time. Examining the contribution of peak morning and afternoon travel time and neighborhood characteristics to the number of housing transactions yielded a significant effect only for the interaction between neighborhood characteristics and each of the two travel times, whereas travel time per se was not found to be significant.

## 6. Discussion and Conclusions

In this paper, we examined the relations between the development of new residential neighborhoods and transportation infrastructure. The assumption underlying this study is that compatibility between all urban services a city provides its residents, especially between transportation infrastructure and residential development, is a necessary condition for a good, just, and sustainable city [8].

We focused on Israel, which in recent years, but especially following the social protest in the summer of 2011 against the high cost of living in general and housing prices in particular, has undergone rapid and intensive new residential neighborhood development accompanied by inadequate development of the required transportation infrastructure. The paper examined the results of this policy—incompatibility between residential and transportation development—and discussed their socioeconomic implications. This was conducted by applying Tiebout's (1965) [24] model of club goods, which introduced the spatial dimension into the theory of club goods by treating neighborhoods as clubs and their residents as club members, actors who make location decisions. This approach made it possible to explore the residents' spatial behavior in light of the incompatibility of the neighborhoods' transportation infrastructure with residential development.

On the basis of two datasets, we examined the relations between traffic congestion (in terms of travel time) and neighborhood size (in terms of number of households). We ran a 2SLS model to estimate the effect of three different travel times (morning peak, afternoon peak, and daily average) and found a negative correlation between an increase in travel time and the number of housing transactions completed in the neighborhood in all three travel times. These findings confirmed Tiebout's assumption that people vote with their feet, implying that when traffic congestion increases, they prefer to leave their current neighborhood and move, most likely to another neighborhood with greater transportation accessibility.

This is a good place to begin commenting on the socioeconomic impacts of travel time, housing transactions, and internal migration, or to ask: What contributes to neighborhood homogeneity? Our findings indicate a positive relation between transactions and prices. We found that the greater the number of transactions, the higher the prices. We also found a negative relation between travel time, the number of transactions, and neighborhood size: The longer the travel time, the fewer the number of transactions and the smaller the neighborhood. These findings suggest the need to expand future research to include more-particularized, more-refined, but related variables than those examined within the limited framework of the current study.

The same findings also raise the related questions: *Which households are more likely to leave the neighborhood? And what are the social implications of such trends*? As already noted, those who vote with their feet are those who can absorb the associated costs, that is, more-affluent households. We can therefore assume that those households remaining within an inefficient club or neighborhood tend to belong to socioeconomically weaker populations that lack the economic resources for moving to a club offering a more attractive package of benefits. Over time, this situation can deepen socioeconomic and spatial gaps by effectively creating two types of homogeneous neighborhoods, those containing a strong population and having transportation (and other) infrastructure in line with the residential development, and those containing weak populations and lacking adequate transportation (and other) infrastructure. Our research provides a first look into the effect of the main variables assumed to affect this process.

Israel, due to drastic changes in its neighborhood development policies and the almost constant inadequate supply of housing—all in a short time span—provides an excellent case for studying the impacts of the major variables we have begun to explore. If we consider the implications of our findings in the context of the Israeli government's policy of massive residential development—requiring construction of more than 400,000 housing units in the latter half of the 2010s—the anticipated consequences are expected to be exacerbated in the coming years. According to the National Planning Administration's annual reports (2018, 2019) [62,63], of 424,000 planned housing units, approximately 40% are for the Central District. Currently, the construction of only 226,510 housing units has been already approved. This forecast rests on the magnitude of deviations from the national and district plans: about 50% of all deviations concerned concessions in the sphere of transportation and road development [62,63], especially in the Central District, on which the study focused.

In 2019, the State Comptroller published an in-depth report on the transportation crisis in Israel and its lateral effects on Israel's society and economy [64]. The report states that "traffic density on Israeli roads is the highest in the OECD countries, 3.5 times the average in these countries . . . Israeli residents face a difficult and oppressive transportation reality on a daily basis. This is not at all a matter of discomfort. This reality impairs labor productivity; leads to the nonrealization of the potential of gross domestic product and tax revenues; contributes to air pollution and noise hazards. Mayors in Israel, especially in the Central District, are warning of a transport disaster that will keep the affluent populations away from the new neighborhoods that are being built". Israel Gal, the mayor of Kiryat Ono, for example, warns of the incompatibility between residential and transportation development: "How much more can be built without transportation infrastructure? I do not see my residents wanting to live in a city that does not offer these basic things. Residential without infrastructure produces serious problems in the long run" [65].

The findings of the study shed a warning light on the potential socioeconomic consequences of the incompatibility between residential and transportation infrastructure development. Studies have shown that households currently moving to new neighborhoods in the Central District are primarily upper middle class—more affluent than the local residents—and therefore have the potential to create a diverse environment and to improve the socioeconomic status of these municipalities [50]. However, the study's findings show that traffic congestion can reverse this trend in the long run and may create homogeneous neighborhoods in which mainly disadvantaged populations remain.

We found that many residents leave these neighborhoods even before most of the projects' approved housing units have been built and occupied. It can be assumed that those leaving are the more-affluent households seeking to improve their transportation accessibility as well as housing conditions, and those that remain lack the resources to move. It can be further assumed that in the foreseeable future, these neighborhoods and localities will decline in terms of socioeconomic status and become the homogeneous neighborhoods predicted by Tiebout's model. Such urban planning is not only unjust, it is also unsustainable over time because both practical and theoretical experience show that homogeneous neighborhoods with a high concentration of disadvantaged residents and inadequate infrastructure may deteriorate into slums, becoming sources of violence and crime and harming the quality of life of all of the city's residents. Socially diverse neighborhoods, on the other hand, are seen as essential for broader community well-being and for achieving social-equity goals [66–70].

Furthermore, the research findings also shed light on the unsustainability of long distances between the residence and the workplace, even before the air pollution they create and the environmental consequences are taken into account. Studies show that workers living in denser, central, compact, and mixed zones make more intense use of public transit and nonmotorized modes of transportation and tend to have lower car ownership levels than those living in more remote areas served by freeways, who tend to make more intense use of their cars [71,72]. Moreover, this situation is also neither sustainable nor egalitarian from a gender perspective. Studies show that as the distance between residence and workplace increases, women pay a higher price, in terms of both income level and type of work [58].

Despite the study's limited and preliminary scope, it makes some important contributions. Whereas the literature on club goods deals primarily with positive incentives such as increases in the supply of newly constructed housing units, we argue that those incentives have a positive effect on the propensity of members of other clubs (neighborhoods) to relocate to the respective club, thereby increasing its size. Spatial equilibrium is thus attained when no further welfare gains are conferred by the available clubs and their spatial distribution.

In contrast, this study deals with a major negative spatial incentive, namely, traffic congestion, which affects the propensity of the club's members (that is, current neighborhood residents) to relocate. In this case, we surmise that rising levels of daily commuter traffic congestion between home and work as well as other destinations are likely to induce residents to relocate, thereby reducing the club's (the neighborhood's) size. Moreover, this study refers to the residents' decision to "stay in the club" as a dynamic process, whose spatial equilibrium outcome is quite difficult to determine a priori. A further dynamic element, relating to traffic congestion, is that neighborhood residents, for various reasons such as the costs of relocation, usually do not base such decisions on the current congestion level. Rather, the change in congestion over time acts as the critical factor. As an initial attempt to confirm this scenario, we collected data on traffic congestion in two consecutive years ($t$ and $t-1$). We therefore suggest that our assumption be revised as follows: A neighborhood's residents are more responsive to changes in the cumulative level of congestion than to its absolute level in a given year.

These unwanted consequences are not a decree from heaven, but the result of bad urban planning decisions. This is the result of a policy in which planning institutions made planning decisions without defining a vision and overarching goals, but rather by means of unsustainable ad hoc decisions aimed at solving problems in the immediate term, often by bypassing existing planning procedures and without going through all the existing planning stages.

What can be done to prevent these unwanted social consequences? First, we must recognize the fact that urban planning deals with a variety of urban and regional systems and infrastructures that must work in sync with each other. Thus, one must plan comprehensively. This means that residential neighborhoods cannot be developed apart from the transportation, education, and health infrastructure. Second, infrastructure (especially, but not only, transportation) must be developed before constructing residential units. As is well-known, the development of transportation infrastructure is particularly complex and takes more time than residential development. Therefore, proper planning should take into account the schedule of all types of development and create a comprehensive plan that will allow the resident to enter the new housing unit when access roads and accessibility to essential and necessary public services (such as education and health services) already exist. Third, and most important, one must plan and execute development in an orderly and logical manner, free of political pressure. Programs that bypass the existing planning stages not only do not solve problems but often create new and more significant problems that are more difficult to solve.

Holistic planning that follows these recommendations and that generates compatibility between all public services and infrastructure that a city provides its residents, especially between transportation infrastructure and residential development, is a necessary condition for a good, just, and sustainable city [8]. For now, however, a separation between the government's policy and good planning decisions that put the quality of life of individuals and groups in the center is a vision, but an unlikely scenario.

**Author Contributions:** R.H., conceptualization, methodology, writing, editing, funding acquisition, supervision, project administration; J.B., conceptualization, methodology, review and editing; S.A.-V., empirical analysis. All authors have read and agreed to the published version of the manuscript.

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**Conflicts of Interest:** The authors declare no conflict of interest.

## Appendix A

**Table A1.** The neighborhoods selected within Central District municipalities.

| | Municipality | Neighborhood | No. of Populated Residential Units, 2019 | No. of Transactions, 2011–2019 |
|---|---|---|---|---|
| 1 | Be'er Ya'akov | Hataney Pras Israel, Tlamim | 1383 | 427 |
| 2 | Be'er Ya'akov | Park HaMoshava | 2390 | 777 |
| 3 | Gadera | Young Gadera | 1976 | 866 |
| 4 | Hod HaSharon | 1200 Compound | 1931 | 1452 |
| 5 | Yavne | Green Yavne | 3903 | 2179 |
| 6 | Kfar Sava | Gane Hasharon, Young Kfar Sava | 1658 | 347 |
| 7 | Kfar Sava | HaZemer Ha'Ivri | 2115 | 1084 |
| 8 | Kfar Sava | Green Kfar Sava | 2446 | 1256 |
| 9 | Nes Tziyona | Argaman, Malibu, Ha'Hadarim Valley | 2436 | 408 |
| 10 | Nes Tziyona | Gane Iris, HaTor Hill, Michael Hill | 907 | 178 |
| 11 | Nes Tziyona | The Vally, Kfar Aharon, Tirat Shalom | 1657 | 371 |
| 12 | Nes Tziyona | Lev Ha'Moshava, Savioney Netzere, HaDegel | 1882 | 602 |
| 13 | Netania | Agamim | 1792 | 1454 |
| 14 | Netania | Ir Yamim | 2638 | 2007 |
| 15 | Petah Tikva | Gane Hadar | 1605 | 331 |
| 16 | Petah Tikva | Hadar Ganim | 1764 | 356 |
| 17 | Petah Tikva | Hadar Ganim | 1432 | 530 |
| 18 | Petah Tikva | New Em HaMoshavot | 2319 | 1075 |
| 19 | Petah Tikva | New Em HaMoshavot | 3677 | 1428 |
| 20 | Petah Tikva | Kfar Ganim C East | 2467 | 595 |
| 21 | Petah Tikva | Kfar Ganim C | 2590 | 527 |
| 22 | Petah Tikva | Neve Gan | 4492 | 1742 |
| 23 | Kadima-Zoran | Tzoran | 1594 | 465 |
| 24 | Kadima-Zoran | Ramat Amir | 900 | 182 |
| 25 | Rosh Ha'Ayn | New Rosh Ha'Ayn | NA | 588 |
| 26 | Rosh Ha'Ayn | New Rosh Ha'Ayn | NA | 94 |
| 27 | Rosh Ha'Ayn | New Rosh Ha'Ayn | 1671 | 711 |
| 28 | Rosh Ha'Ayn | New Rosh Ha'Ayn | NA | 213 |
| 29 | Rosh Ha'Ayn | New Rosh Ha'Ayn | 701 | 403 |
| 30 | Rosh Ha'Ayn | New Rosh Ha'Ayn | 2934 | 2553 |
| 31 | Rosh Ha'Ayn | Rambam | 2079 | 604 |
| 32 | Rishon LeZion | Nahalat Yehuda | 3642 | 1211 |
| 33 | Rishon LeZion | Sha'ar HaYam | 528 | 391 |
| 34 | Rehovot | Neve Amit & Ginot Savyon | 494 | 115 |
| 35 | Rehovot | Dutch Rehuvot | 2392 | 1018 |
| 36 | Rehovot | Science & Weizman Area | 2733 | 730 |
| 37 | Shoham | Vradim, Yovalim, Rakafot, 21 | 1175 | 461 |
| 38 | Shoham | Tlalim, Giv'olim, Kramim | 1445 | 236 |
| 39 | Shoham | Yaelim, Sahlavim, Hamaniyot | 1655 | 435 |

## Appendix B

```
. reg3 (lhh lhh_dens l1.lcount)(lcount L1.lafternoon lpricecurrent i.year i.mapstat ) ,2sls

Two-stage least-squares regression
----------------------------------------------------------------------
Equation          Obs   Parms        RMSE    "R-sq"     F-Stat        P
----------------------------------------------------------------------
lhh                72       2    .4266045    0.3861      21.69   0.0000
lcount             72      38    .7138962    0.8578       5.24   0.0000
----------------------------------------------------------------------

------------------------------------------------------------------------------
              |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
--------------+---------------------------------------------------------------
lhh           |
     lhh_dens |   .4255038   .0901375     4.72   0.000     .2467165     .604291
              |
       lcount |
          L1. |   .1177858   .0455892     2.58   0.011     .0273598    .2082117
              |
        _cons |   3.535678   .6940501     5.09   0.000     2.159033    4.912323
--------------+---------------------------------------------------------------
lcount        |
   lafternoon |
          L1. |  -4.482699   .8882364    -5.05   0.000    -6.244512   -2.720886
              |
lpricecurrent |   2.032355   .5443353     3.73   0.000     .9526685    3.112042
      18.year |   .8417912   .1880747     4.48   0.000      .468746    1.214836
              |
      mapstat |
     1950002  |   1.280052   .7141503     1.79   0.076     -.136462    2.696565
    13040001  |   1.783176   .8623608     2.07   0.041     .0726875    3.493665
    13040002  |   1.389193   .8385581     1.66   0.101    -.2740834    3.052468
    13040003  |   3.461824   .8413375     4.11   0.000     1.793035    5.130613
    25500005  |    1.16322    .718197     1.62   0.108    -.2613204     2.58776
    26400002  |   4.676883   .9081362     5.15   0.000     2.875599    6.478167
    69000015  |   2.821997   .9527501     2.96   0.004     .9322215    4.711772
    72000002  |   .0690999     .76601     0.09   0.928    -1.450277    1.588477
    72000005  |  -.6846911   .7491548    -0.91   0.363    -2.170636    .8012539
    72000006  |  -.2872645    .744074    -0.39   0.700    -1.763132    1.188603
    72000011  |   .4433398   .7518007     0.59   0.557    -1.047853    1.934533
    74000414  |   4.690102    .914987     5.13   0.000     2.875229    6.504974
    74000531  |   4.972483   .9485186     5.24   0.000     3.091101    6.853865
    79000115  |   4.588728    .877327     5.23   0.000     2.848554    6.328902
    79000121  |   4.015978   .8678317     4.63   0.000     2.294638    5.737318
    79000129  |   4.293014   .8697127     4.94   0.000     2.567943    6.018085
    79000212  |    2.59896   .8026763     3.24   0.002     1.006855    4.191064
    79000214  |   1.888841   .7835137     2.41   0.018     .3347451    3.442936
    79000521  |   2.684747    .807563     3.32   0.001      1.08295    4.286545
    79000522  |   2.405175    .813419     2.96   0.004     .7917619    4.018587
    79000523  |   2.650202   .8076227     3.28   0.001     1.048286    4.252117
    83000311  |   2.199498   .7520219     2.92   0.004     .7078657     3.69113
    83000625  |  -.6223148   .7861174    -0.79   0.430    -2.181575    .9369454
    84000123  |   3.277829   .8273229     3.96   0.000     1.636838     4.91882
    84000422  |   .6438818   .7837874     0.82   0.413    -.9107568     2.19852
    84000424  |   1.794048    .757983     2.37   0.020     .2905922    3.297504
    99991191  |   2.761022   .7398881     3.73   0.000     1.293457    4.228586
    99991199  |    2.04565   .7352021     2.78   0.006     .5873797    3.503919
    99991231  |   3.698065   .9459648     3.91   0.000     1.821748    5.574382
    99991255  |   2.437376   .9159575     2.66   0.009      .620579    4.254174
    99991289  |   5.848677   .9154166     6.39   0.000     4.032953    7.664402
    99991290  |     5.5025   .9047511     6.08   0.000     3.707931     7.29707
    99991387  |   3.640544   .7513218     4.85   0.000     2.150301    5.130787
    99991436  |   5.333536    .973762     5.48   0.000     3.402083    7.264988
    99991441  |   6.015234    .905968     6.64   0.000      4.21825    7.812217
              |
        _cons |  -22.54733   5.139766    -4.39   0.000    -32.74203   -12.35262
------------------------------------------------------------------------------
Endogenous variables:  lhh lcount
Exogenous variables:   lhh_dens L.lcount L.lafternoon lpricecurrent 17.year
     18.year 1950001.mapstat 1950002.mapstat 13040001.mapstat
     13040002.mapstat 13040003.mapstat 25500005.mapstat 26400002.mapstat
     69000015.mapstat 72000002.mapstat 72000005.mapstat 72000006.mapstat
     72000011.mapstat 74000414.mapstat 74000531.mapstat 79000115.mapstat
     79000121.mapstat 79000129.mapstat 79000212.mapstat 79000214.mapstat
     79000521.mapstat 79000522.mapstat 79000523.mapstat 83000311.mapstat
     83000625.mapstat 84000123.mapstat 84000422.mapstat 84000424.mapstat
     99991191.mapstat 99991199.mapstat 99991231.mapstat 99991255.mapstat
     99991289.mapstat 99991290.mapstat 99991387.mapstat 99991436.mapstat
     99991441.mapstat
------------------------------------------------------------------------------
```

**Figure A1.** *Cont.*

```
. reg3 (lhh lhh_dens l1.lcount)(lcount L1.ldaypeak lpricecurrent i.year i.mapstat ) ,2sls

Two-stage least-squares regression
----------------------------------------------------------------------
Equation             Obs   Parms        RMSE    "R-sq"     F-Stat        P
----------------------------------------------------------------------
lhh                   72       2    .4266045    0.3861      21.69   0.0000
lcount                72      38    .8285345    0.8085       3.67   0.0000
----------------------------------------------------------------------

------------------------------------------------------------------------------
              |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
--------------+---------------------------------------------------------------
lhh           |
     lhh_dens |   .4255038   .0901375     4.72   0.000     .2467165     .604291
              |
       lcount |
          L1. |   .1177858   .0455892     2.58   0.011     .0273598    .2082117
              |
        _cons |   3.535678   .6940501     5.09   0.000     2.159033    4.912323
--------------+---------------------------------------------------------------
lcount        |
     ldaypeak |
          L1. |  -6.000724   1.859948    -3.23   0.002    -9.689922   -2.311527
              |
lpricecurrent |   2.212688   .6287176     3.52   0.001     .9656294    3.459746
      18.year |   .2545172   .2046185     1.24   0.216    -.1513426    .6603769
              |
      mapstat |
     1950002  |   1.401683    .828625     1.69   0.094    -.2418907    3.045257
     13040001 |   2.846601   1.325112     2.15   0.034     .2182468    5.474955
     13040002 |   2.606143   1.302205     2.00   0.048     .0232262     5.18906
     13040003 |   4.748887   1.250458     3.80   0.000      2.26861    7.229164
     25500005 |    3.36352   .9996406     3.36   0.001     1.380738    5.346303
     26400002 |   4.016622   1.066536     3.77   0.000     1.901153    6.132091
     69000015 |    2.22437   1.143821     1.94   0.055     -.044393    4.493134
     72000002 |   2.731219   1.284236     2.13   0.036     .1839434    5.278495
     72000005 |   1.963495   1.292134     1.52   0.132    -.5994458    4.526436
     72000006 |   2.554952    1.26302     2.02   0.046     .0497586    5.060145
     72000011 |   3.225926   1.372721     2.35   0.021     .5031404    5.948713
     74000414 |   5.790411   1.478115     3.92   0.000     2.858577    8.722245
     74000531 |   5.944733   1.490233     3.99   0.000     2.988862    8.900604
     79000115 |   4.955301   1.213051     4.08   0.000     2.549219    7.361382
     79000121 |   4.569847   1.233747     3.70   0.000     2.122717    7.016978
     79000129 |   4.844693   1.235622     3.92   0.000     2.393842    7.295545
     79000212 |   3.688448   1.161667     3.18   0.002     1.384286     5.99261
     79000214 |   2.860879   1.088185     2.63   0.010     .7024694    5.019289
     79000521 |     4.0521   1.281053     3.16   0.002     1.511138    6.593062
     79000522 |   3.765261   1.286844     2.93   0.004     1.212812    6.317711
     79000523 |   4.040487   1.293521     3.12   0.002     1.474794    6.606181
     83000311 |    3.75685   1.009986     3.72   0.000     1.753548    5.760152
     83000625 |   1.288459   1.128574     1.14   0.256    -.9500621     3.52698
     84000123 |   5.415277   1.514584     3.58   0.001     2.411106    8.419447
     84000422 |   3.025923   1.410437     2.15   0.034     .2283279    5.823518
     84000424 |   4.261507   1.337986     3.19   0.002     1.607618    6.915395
     99991191 |   4.506026   1.139477     3.95   0.000     2.245879    6.766173
     99991199 |   4.192378   1.211649     3.46   0.001     1.789078    6.595677
     99991231 |   2.861057   1.082136     2.64   0.009      .714645     5.00747
     99991255 |   1.504284   1.021274     1.47   0.144    -.5214081    3.529976
     99991289 |   5.511967   1.144616     4.82   0.000     3.241627    7.782307
     99991290 |   5.200238   1.134506     4.58   0.000      2.94995    7.450526
     99991387 |   6.450563     1.4791     4.36   0.000     3.516774    9.384351
     99991436 |   4.502814   1.130937     3.98   0.000     2.259606    6.746023
     99991441 |   5.705947   1.135545     5.02   0.000       3.4536    7.958294
              |
        _cons |  -26.50878   6.186378    -4.29   0.000    -38.77943   -14.23813
------------------------------------------------------------------------------
Endogenous variables:  lhh lcount
Exogenous variables:   lhh_dens L.lcount L.ldaypeak lpricecurrent 17.year
     18.year 1950001.mapstat 1950002.mapstat 13040001.mapstat
     13040002.mapstat 13040003.mapstat 25500005.mapstat 26400002.mapstat
     69000015.mapstat 72000002.mapstat 72000005.mapstat 72000006.mapstat
     72000011.mapstat 74000414.mapstat 74000531.mapstat 79000115.mapstat
     79000121.mapstat 79000129.mapstat 79000212.mapstat 79000214.mapstat
     79000521.mapstat 79000522.mapstat 79000523.mapstat 83000311.mapstat
     83000625.mapstat 84000123.mapstat 84000422.mapstat 84000424.mapstat
     99991191.mapstat 99991199.mapstat 99991231.mapstat 99991255.mapstat
     99991289.mapstat 99991290.mapstat 99991387.mapstat 99991436.mapstat
     99991441.mapstat
------------------------------------------------------------------------------
```

**Figure A1.** *Cont*.

```
. reg3 (lhh lhh_dens l1.lcount)(lcount lmorningpeak lpricecurrent i.year i.mapstat ) ,2sls

Two-stage least-squares regression
----------------------------------------------------------------------
Equation          Obs   Parms        RMSE    "R-sq"     F-Stat        P
----------------------------------------------------------------------
lhh               106       2    .4380888    0.3756      30.99   0.0000
lcount            106      39    .7563485    0.7300       4.58   0.0000
----------------------------------------------------------------------

------------------------------------------------------------------------------
              |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
--------------+---------------------------------------------------------------
lhh           |
     lhh_dens |   .4669919   .0708997     6.59   0.000     .3270288    .6069549
              |
       lcount |
          L1. |    .125834   .0363431     3.46   0.001     .0540892    .1975789
              |
        _cons |   3.152956   .5784919     5.45   0.000     2.010955    4.294957
--------------+---------------------------------------------------------------
lcount        |
 lmorningpeak |  -4.128423   1.271953    -3.25   0.001    -6.639387   -1.617459
lpricecurrent |   1.580407   .4834481     3.27   0.001     .6260313    2.534782
              |
         year |
           17 |  -.5899935    .191192    -3.09   0.002    -.9674256   -.2125614
           18 |   .0523135   .2139958     0.24   0.807    -.3701356    .4747626
              |
      mapstat |
     1950002  |   .6831278   .6176767     1.11   0.270    -.5362281    1.902484
    13040001  |   .9843873   .7765539     1.27   0.207    -.5486082    2.517383
    13040002  |   .8779589   .7543865     1.16   0.246    -.6112757    2.367194
    13040003  |   1.814844    .706584     2.57   0.011     .4199762    3.209712
    25500005  |    1.35165   .6175591     2.19   0.030     .1325262    2.570774
    26400002  |   1.351684    .619699     2.18   0.031     .1283362    2.575032
    69000015  |   .4987916   .6727008     0.74   0.459    -.8291874    1.826771
    72000002  |   2.583925   1.006328     2.57   0.011     .5973326    4.570516
    72000005  |   1.769834   1.018351     1.74   0.084     -.240494    3.780162
    72000006  |   2.728553   1.064818     2.56   0.011     .6264958    4.830609
    72000011  |   2.815772   1.112719     2.53   0.012     .6191529    5.012392
    74000414  |   3.225354   .7669713     4.21   0.000     1.711276    4.739433
    74000531  |   2.963913   .7433735     3.99   0.000     1.496419    4.431407
    79000115  |   2.121567   .6362817     3.33   0.001     .8654834    3.377651
    79000121  |   1.855914   .6519593     2.85   0.005     .5688804    3.142947
    79000129  |   2.356174   .6525594     3.61   0.000     1.067956    3.644391
    79000212  |     1.7947   .6879956     2.61   0.010     .4365273    3.152872
    79000214  |   .7560631   .6560102     1.15   0.251     -.538967    2.051093
    79000521  |   2.283323   .7431292     3.07   0.002     .8163114    3.750335
    79000522  |    1.86166   .7474167     2.49   0.014     .3861846    3.337136
    79000523  |   2.057336   .7444866     2.76   0.006     .5876449    3.527028
    83000311  |   3.346032   .8263924     4.05   0.000     1.714651    4.977414
    83000625  |   1.219332   .9048589     1.35   0.180    -.5669507    3.005614
    84000123  |   4.164685   1.126646     3.70   0.000     1.940571    6.388798
    84000422  |   2.512731   1.148721     2.19   0.030     .2450406    4.780422
    84000424  |   4.290249   1.171853     3.66   0.000     1.976894    6.603604
    99991191  |   3.745118   .9164073     4.09   0.000     1.936037    5.554198
    99991199  |   2.836462   .8308718     3.41   0.001     1.196237    4.476686
    99991231  |   1.269694   .6488565     1.96   0.052    -.0112138    2.550602
    99991255  |   .1543012   .6403469     0.24   0.810    -1.109808     1.41841
    99991289  |   3.577552   .6749305     5.30   0.000     2.245171    4.909932
    99991290  |   2.678534   .6714192     3.99   0.000     1.353085    4.003983
    99991387  |   5.198383   1.118549     4.65   0.000     2.990256     7.40651
    99991436  |   1.585724   .7160389     2.21   0.028     .1721912    2.999257
    99991441  |   3.855444   .7597532     5.07   0.000     2.355615    5.355273
              |
        _cons |  -16.52861   4.695871    -3.52   0.001    -25.79874   -7.258492
------------------------------------------------------------------------------
Endogenous variables:  lhh lcount
Exogenous variables:   lhh_dens L.lcount lmorningpeak lpricecurrent 16.year
     17.year 18.year 1950001.mapstat 1950002.mapstat 13040001.mapstat
     13040002.mapstat 13040003.mapstat 25500005.mapstat 26400002.mapstat
     69000015.mapstat 72000002.mapstat 72000005.mapstat 72000006.mapstat
     72000011.mapstat 74000414.mapstat 74000531.mapstat 79000115.mapstat
     79000121.mapstat 79000129.mapstat 79000212.mapstat 79000214.mapstat
     79000521.mapstat 79000522.mapstat 79000523.mapstat 83000311.mapstat
     83000625.mapstat 84000123.mapstat 84000422.mapstat 84000424.mapstat
     99991191.mapstat 99991199.mapstat 99991231.mapstat 99991255.mapstat
     99991289.mapstat 99991290.mapstat 99991387.mapstat 99991436.mapstat
     99991441.mapstat
------------------------------------------------------------------------------
```

**Figure A1.** Model regression outcomes.

## Appendix C

```
. anova lcount mapstat##factorlafternoon

                         Number of obs =        326    R-squared     =  0.4587
                         Root MSE      =    1.02988    Adj R-squared =  0.3233

                  Source | Partial SS         df         MS        F    Prob>F
              -----------+----------------------------------------------------
                   Model |  233.65502         65   3.5946926      3.39  0.0000
                         |
                 mapstat |  165.01534         38   4.3425089      4.09  0.0000
            factorlaf~n  |  1.0680394          1   1.0680394      1.01  0.3166
      mapstat#factorlaf~n|  35.287526         26   1.3572126      1.28  0.1702
                         |
                Residual |  275.77173        260   1.0606605
              -----------+----------------------------------------------------
                   Total |  509.42675        325   1.5674669

. anova lhh mapstat#factorlafternoon

                         Number of obs =        262    R-squared     =  0.7904
                         Root MSE      =    .308297    Adj R-squared =  0.7265

                  Source | Partial SS         df         MS        F    Prob>F
              -----------+----------------------------------------------------
                   Model |  71.694229         61   1.1753152     12.37  0.0000
                         |
      mapstat#factorlaf~n|  71.694229         61   1.1753152     12.37  0.0000
                         |
                Residual |  19.009419        200    .0950471
              -----------+----------------------------------------------------
                   Total |  90.703648        261   .34752356

. anova lhh mapstat##factorlafternoon

                         Number of obs =        262    R-squared     =  0.7904
                         Root MSE      =    .308297    Adj R-squared =  0.7265

                  Source | Partial SS         df         MS        F    Prob>F
              -----------+----------------------------------------------------
                   Model |  71.694229         61   1.1753152     12.37  0.0000
                         |
                 mapstat |  64.782767         35   1.8509362     19.47  0.0000
            factorlaf~n  |  1.8896942          1   1.8896942     19.88  0.0000
      mapstat#factorlaf~n|  2.6023359         25   .10409344      1.10  0.3507
                         |
                Residual |  19.009419        200    .0950471
              -----------+----------------------------------------------------
                   Total |  90.703648        261   .34752356
```

**Figure A2.** *Cont.*

```
. anova lhh mapstat## fatormorning

                         Number of obs =        262    R-squared     =  0.8289
                         Root MSE      =    .276521    Adj R-squared =  0.7800

                  Source | Partial SS         df         MS        F    Prob>F
     --------------------+----------------------------------------------------
                   Model |  75.181447         58   1.2962318     16.95  0.0000
                         |
                 mapstat |  63.485446         35   1.8138699     23.72  0.0000
             fatormorn~g |  3.5168198          1   3.5168198     45.99  0.0000
     mapstat#fatormorn~g |  5.0391659         22     .229053      3.00  0.0000
                         |
                Residual |  15.522202        203   .07646405
     --------------------+----------------------------------------------------
                   Total |  90.703648        261   .34752356
```

```
. anova lcount mapstat## fatormorning

                         Number of obs =        326    R-squared     =  0.4662
                         Root MSE      =    1.02269    Adj R-squared =  0.3328

                  Source | Partial SS         df         MS        F    Prob>F
     --------------------+----------------------------------------------------
                   Model |  237.49649         65   3.6537921      3.49  0.0000
                         |
                 mapstat |  180.84273         38   4.7590193      4.55  0.0000
             fatormorn~g |  .01139876          1   .01139876      0.01  0.9169
     mapstat#fatormorn~g |  40.770547         26   1.5680979      1.50  0.0610
                         |
                Residual |  271.93026        260   1.0458856
     --------------------+----------------------------------------------------
                   Total |  509.42675        325   1.5674669
```

```
. anova lcount factorlafternoon##lpricecurrent_cat

                         Number of obs =        326    R-squared     =  0.0212
                         Root MSE      =    1.24438    Adj R-squared =  0.0121

                  Source | Partial SS         df         MS        F    Prob>F
  -----------------------+----------------------------------------------------
                   Model |  10.818476          3   3.6061588      2.33  0.0744
                         |
             factorlaf~n |  9.7097823          1   9.7097823      6.27  0.0128
             lpricecu~at |  .06383113          1   .06383113      0.04  0.8392
 factorlaf~n#lpricecu~at |  .68904892          1   .68904892      0.44  0.5052
                         |
                Residual |  498.60827        322   1.5484729
  -----------------------+----------------------------------------------------
                   Total |  509.42675        325   1.5674669
```

**Figure A2.** *Cont.*

```
. anova lcount factorlafternoon#lpricecurrent_cat

                         Number of obs =        326    R-squared     =  0.0212
                         Root MSE      =    1.24438    Adj R-squared =  0.0121

                  Source | Partial SS         df         MS        F    Prob>F
  -----------------------+----------------------------------------------------
                   Model |  10.818476          3   3.6061588     2.33  0.0744
                         |
factorlaf~n#lpricecu~at  |  10.818476          3   3.6061588     2.33  0.0744
                         |
                Residual |  498.60827        322   1.5484729
  -----------------------+----------------------------------------------------
                   Total |  509.42675        325   1.5674669

. anova lcount fatormorning #lpricecurrent_cat

. anova lcount fatormorning#lpricecurrent_cat

                         Number of obs =        326    R-squared     =  0.0112
                         Root MSE      =    1.25077    Adj R-squared =  0.0019

                  Source | Partial SS         df         MS        F    Prob>F
  -----------------------+----------------------------------------------------
                   Model |  5.6844938          3   1.8948313     1.21  0.3057
                         |
 fatormorn~g#lpricecu~at |  5.6844938          3   1.8948313     1.21  0.3057
                         |
                Residual |  503.74226        322   1.5644169
  -----------------------+----------------------------------------------------
                   Total |  509.42675        325   1.5674669

. anova lcount fatormorning##lpricecurrent_cat

                         Number of obs =        326    R-squared     =  0.0112
                         Root MSE      =    1.25077    Adj R-squared =  0.0019

                  Source | Partial SS         df         MS        F    Prob>F
  -----------------------+----------------------------------------------------
                   Model |  5.6844938          3   1.8948313     1.21  0.3057
                         |
             fatormorn~g |  .44544382          1   .44544382     0.28  0.5940
             lpricecu~at |  .00024357          1   .00024357     0.00  0.9901
 fatormorn~g#lpricecu~at |  3.4027438          1   3.4027438     2.18  0.1412
                         |
                Residual |  503.74226        322   1.5644169
  -----------------------+----------------------------------------------------
                   Total |  509.42675        325   1.5674669
```

**Figure A2.** *Cont.*

```
. anova lcount factorlafternoon## mapstat
```

Number of obs = 326 R-squared = 0.4587
Root MSE = 1.02988 Adj R-squared = 0.3233

| Source | Partial SS | df | MS | F | Prob>F |
|---|---|---|---|---|---|
| Model | 233.65502 | 65 | 3.5946926 | 3.39 | 0.0000 |
| factorlaf~n | 1.0680394 | 1 | 1.0680394 | 1.01 | 0.3166 |
| mapstat | 165.01534 | 38 | 4.3425089 | 4.09 | 0.0000 |
| factorlaf~n#mapstat | 35.287526 | 26 | 1.3572126 | 1.28 | 0.1702 |
| Residual | 275.77173 | 260 | 1.0606605 | | |
| Total | 509.42675 | 325 | 1.5674669 | | |

```
. anova lcount fatormorning##lpricecurrent_cat
```

Number of obs = 326 R-squared = 0.0112
Root MSE = 1.25077 Adj R-squared = 0.0019

| Source | Partial SS | df | MS | F | Prob>F |
|---|---|---|---|---|---|
| Model | 5.6844938 | 3 | 1.8948313 | 1.21 | 0.3057 |
| fatormorn~g | .44544382 | 1 | .44544382 | 0.28 | 0.5940 |
| lpricecu~at | .00024357 | 1 | .00024357 | 0.00 | 0.9901 |
| fatormorn~g#lpricecu~at | 3.4027438 | 1 | 3.4027438 | 2.18 | 0.1412 |
| Residual | 503.74226 | 322 | 1.5644169 | | |
| Total | 509.42675 | 325 | 1.5674669 | | |

**Figure A2.** ANOVA outcomes.

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