CAN'T GET THERE FROM HERE: AFFORDABILITY DISTANCE TO A SUPERSTAR CITY

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ABSTRACT

This paper explores the housing affordability distance to a superstar city. Affordability distance is defined in terms of the increment to household income required to consume a quality- and consumption-adjusted housing unit in the proximate superstar city. The analysis focuses on Tel Aviv, Israel's singular superstar city. Affordability distance to Tel Aviv rose by roughly 60 percent over the 2000 – 2015 period. Further, affordability distance was elevated among unmarried, non-college educated, and immigrant households. The upward movement in affordability distance was associated with increased out-migration from the city. Analysis of panel data suggests that policy interventions including investment in regional transportation infrastructure and new local housing supply were effective in mediating affordability distance.

Key Words: affordability distance, superstar city, housing development, transportation infrastructure

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1. INTRODUCTION

A defining characteristic of superstar cities is their elevated rates of house price growth (see Gyourko, Mayer, and Sinai [2013]). In order for growth in prices to persist, a sufficient share of population must hold preferences for superstar locations so as to generate excess demand for those locations in the context of constrained housing supply. Ongoing gains to local productivity or amenities similarly may generate elevated house price growth.

Under certain conditions, however, elevated rates of house price growth may sow the seeds of superstar city demise. House price run-ups, if not accompanied by productivity gains and related wage increases, may reduce nominal affordability so as to put those locations out-of-reach of ordinary households. The decline in nominal affordability may spur net migration of households and jobs in the context of ongoing equilibration across cities. Lack of affordable housing may adversely affect superstar output to the extent low- and high-wage households are complements in production. Regardless, superstar cities may require adequate affordable housing and access for necessary public (e.g., police, fire, teachers, and nurses) and other service workers. Over time, competitor locations may succeed in replicating superstar amenities and economic base so as to further arbitrage house price returns. In the wake of those developments, elected leaders in superstar cities may come under pressure to expand housing supply and access. Those efforts would seek to mediate erosion in housing affordability and local economic base.[1]

In this paper, we study the housing affordability gap between superstar cities and surrounding localities. We put forward a new measure of Affordability Distance to the Superstar City (ADS), defined as the incremental income required for a household to consume a *standardized* housing unit in a proximate superstar city. Affordability distance is computed based on a new quality-and consumption-standardized measure of housing affordability that adjusts for normative variability in housing consumption across households and locations (see Ben-Shahar, Gabriel, and Golan [2017]). We document spatial variation and temporal dynamics in housing affordability distance, identify population characteristics associated with elevated affordability distance, and compute Gini coefficients associated with that measure. We then examine the consequences of affordability distance for superstar city migration flows. Finally, we evaluate the role of numerous policy interventions—including transportation infrastructure investment and superstar city new housing supply—in mediating affordability distance.

[1] Note that local perspectives and related local efforts to enhance housing supply and job access so as to reduce affordability burdens may differ from national perspectives which remain more agnostic about localized outcomes in the context of ongoing spatial equilibration in a system of cities.

The analysis employs individual-level household data from Israel to compute the affordability distance to Tel Aviv. Over the course of recent decades, Tel Aviv has witnessed persistently high rates of house price growth and emerged as Israel's singular superstar city. The Tel Aviv metro area is characterized by unique cultural and natural amenities and is home to Israel's burgeoning tech and innovation sector (e.g., Alfasi and Fenster [2005]).

In computation of affordability distance to the superstar city, we address potential bias inherent in traditional measures of housing affordability. Specifically, the most prevalent measure of affordability, the household housing price-to-income ratio (see, for example, Quigley and Raphael [2004] and Gan and Hill [2009]), may be less informative owing to systematic variation across households in preferences for and consumption of housing services. For example, a household may exhibit higher levels of affordability due to below-standard consumption of housing services. Alternatively, a household may display low levels of affordability owing to above-standard consumption of housing (see Thalmann [1999]).

To address these concerns, we employ information from an extensive Israel micro-level dataset to match individual households to the mean housing consumption bundle of Tel Aviv households with similar demographic characteristics. Such matching allows for systematic variation in preferences and consumption of housing services across household demographic characteristics and over time. That approach recognizes that demographically-adjusted cohorts may consume systematically different combinations of housing and location-specific amenities in superstar and non-superstar locations. Using the hedonic approach, we estimate the price of those normative consumption bundles in the superstar city. Given information on normative consumption bundles, the estimated quality-adjusted pricing thereof in Tel Aviv, the estimated price of the housing consumed in the origin locality, and household net income, we compute the household quality- and consumption-adjusted housing affordability distance (ADS) to the superstar city.[2]

We estimate an ever-widening gap in quality-adjusted house price index levels between Tel Aviv and other areas of Israel over the 2000-2015 period. Further, results show that the affordability distance to Tel Aviv increased by roughly 60 percent over that same timeframe and was especially high among those living in the Israel's peripheral Negev and Galilee regions. Computation of a Gini coefficients on ADS for Israel further indicates elevated levels of

[2] The ADS measure follows Ben-Shahar, Gabriel, and Golan (2017) who introduce a consumption-adjusted housing affordability measure that corrects for the potential bias in the prevalent price-to-income ratio. They show that the new measure gives rise to elevated Gini measures of housing affordability inequality and find that trending up in house prices and income is associated with more pressing consumption-adjusted affordability challenges among those already in housing distress.

affordability distance inequality. We then employ panel data to assess the association between affordability distance and superstar city population flows. Upon accounting for the potential endogeneity, our results confirm that increases in affordability distance to Tel Aviv are associated with increased out-migration from the city. We find that a 10-month net-income increment in affordability distance results in a 6 percent increase in out-migration from Tel Aviv.

As suggested above, leaders in superstar cities may seek to mediate affordability distance because of adverse distributional and job access concerns and to prevent erosion in local economic base. We evaluate policy interventions including both regional transportation infrastructure investment and increments to superstar city housing supply. Findings confirm the efficacy of these drivers in reducing the affordability distance to Tel Aviv. Construction of 100 new housing units in Tel Aviv is associated with a 0.7 percent decrease in the ADS whereas a 1 percentage point of GDP increment in government spending on transportation infrastructure is associated with a 35 percent decrease in ADS. Overall, findings provide new insights as to the role of housing affordability distance in arbitrage of superstar cities. Research findings suggest the efficacy of policy mechanisms including transportation infrastructure investment and housing construction in mediating problems of elevated affordability distance.

The paper is organized as follows. Section 2 introduces and provides methodological foundation for a measure of affordability distance to a superstar city (ADS). Section 3 describes the data and sample, including variable definitions and related summary statistics. In section 4, we compute affordability distance to Tel Aviv. In so doing, we describe housing consumption variability across space and effects of physical distance. Further, we compute the ADS Gini Coefficient as well as assess the association between affordability distance and population characteristics. In Section 5, we evaluate the relation between affordability distance and out-migration from the superstar city and assess the role of policy levers, including new construction and transportation infrastructure investment, in mediating increases in affordability distance to Tel Aviv. Section 6 concludes and discusses implications for policy.

2. THE AFFORDABILITY DISTANCE TO A SUPERSTAR CITY MEASURE

In this paper, we propose a new measure of affordability access to a superstar city. The measure, termed the Affordability Distance to a Superstar City (ADS), computes the incremental months of net income required for a household living outside the superstar city to purchase a quality- and consumption-adjusted housing unit in the proximate superstar city.

We compute the ADS measure as follows: Firstly, we stratify the sample of households by year and basic demographic characteristics to generate mutually exclusive clusters of households, each denoted by *A*, *C*, and *Y* (henceforth *ACY*), where *A* is the number of adults in a household, *A*=(1,2,…,5 and over); *C* is the number of children in a household, *C*=(1,2,…,8 and over); and *Y* is the year in which the household is observed, *Y*=(1998,1999,…,2015). For example, household *i*, $i \in (A = 2, C = 3, Y = 2010)$ describes a household that belongs to a cluster whose characteristics include two adults with three children, observed in 2010.[3]

Next, for each cluster, we use those households who live in the superstar city to compute the *standardized* housing consumption of that cluster in that city. We refer to the "superstar group" of each cluster as ACY^S. The standardized housing consumption of each superstar group, NR_{ACY}^S, is then the average room consumption:

$$NR_{ACY}^S = \sum_i NR_{i \in ACY}^S / N_{ACY}^S, \tag{1}$$

where the index *i* represents households, $NR_{i \in ACY}^S$ is the room consumption of household *i* in cluster ACY and city *S* (superstar city) and N_{ACY}^S is the number of households in ACY and city S.[4]

Thirdly, based on all housing transactions in the housing market, we estimate for each city a hedonic price equation of the form

$$\ln(P_{j \in l}) = \gamma_{1,l} + \gamma_{2,l} NR_{j \in l} + \gamma_{3,l} NR_{j \in l} \times Floor_{j \in l} + \vec{\gamma}_{4,l} CHARACTERISTICS_{j \in l} + \vec{\gamma}_{5,l} TFE_{j \in l} + \varepsilon_{1, j \in l} \text{ for all } l, \tag{2}$$

where the indices *j* and *l* represent housing transactions and cities, respectively; *P* denotes the transaction price; *NR* is the number of rooms in the unit; *Floor* is the floor on which the unit is located in the building (interacted with *NR*); and *CHARACTERISTICS* is a vector of other housing unit characteristics, including, *Age*, the age of the structure in which the unit is located; *DumNew*, a dummy variable that equals one for units whose age is up to 1 year and zero otherwise; and *Floor*. Also, *TFE* is a vector of time (year) fixed-effects, ln(·) is the log operator, $\gamma_1 - \gamma_3$ are estimated parameters, $\vec{\gamma}_4$ and $\vec{\gamma}_5$ are vectors of estimated parameters, and ε_1 is a random disturbance term.

[3] Household clustering by number of adults and number of children is consistent with, among others, previous studies on the correlation between household housing consumption and both the number of adults and number of children. See, for example, Mayo (1981), Bratt *et al.* (2006), Li (2014), Awan *et al.* (1982), Goodman (1990), Swan (1995), and Reed (2002).

[4] In terms of total housing consumption, our data only specifies the number of rooms (including a living room and bedrooms; excluding bathrooms) consumed by each household. It should be noted, however, that in the Israeli context, as more than 90 percent of the residential market consists of condominium apartments (most of which are 2-5 room units), there is limited variability among residential units in terms of room types. Most 1-3-room (4-5-room) units include 1 bathroom (2 bathrooms).

Equation (2) is separately estimated for every city *l* in the sample (one of which is the superstar city) using a linear spline for the *NR*, *AGE*, and *FLOOR* variables.[5]

Following the estimation of equation (2), we compute

$$\hat{P}^{l}_{i\in ACY} = EXP\Big[\hat{\gamma}_{1,l} + \hat{\gamma}_{2,l}NR^{l}_{i\in ACY} + \hat{\gamma}_{3,l}NR^{l}_{i\in ACY} \times Floor^{l}_{i\in ACY} + \hat{\vec{\gamma}}_{4,l}CHARACTERISTICS^{l}_{i\in ACY} + \hat{\vec{\gamma}}_{5,l}TFE^{l}_{i\in ACY} + \hat{\sigma}^{2}_{l}/2\Big] \text{ for all } i \in ACY \text{ and } l \quad (3)$$

and

$$\hat{P}^{S}_{ACY} = EXP\Big[\hat{\gamma}_{1,S} + \hat{\gamma}_{2,S}NR^{S}_{ACY} + \hat{\gamma}_{3,l}NR^{S}_{ACY} \times Floor^{S}_{ACY} + \hat{\vec{\gamma}}_{4,S}CHARACTERISTICS^{S}_{ACY} + \hat{\vec{\gamma}}_{5,S}TFE^{S}_{Y} + \hat{\sigma}^{2}_{l}/2\Big] \text{ for all } ACY \in S, \quad (4)$$

where *i*, *l*, and *S* represent households, cities (other than the superstar city), and the superstar city, respectively; $NR^{l}_{i\in ACY}$, $Floor^{l}_{i\in ACY}$, and $CHARACTERISTICS^{l}_{i\in ACY}$ on the right-hand side of (3) are the actual number of rooms consumed, floor location, and other asset characteristics, respectively, of the housing unit occupied by household *i*, $i \in ACY$ in *l*;[6] NR^{S}_{ACY}, $Floor^{S}_{ACY}$, and $CHARACTERISTICS^{S}_{ACY}$ on the right-hand side of (4) are the standardized number of rooms consumed of the superstar group ACY^{s} (from equation [1]), and floor location as well as a vector of other asset characteristics at their average value across the superstar group ACY^{s}, respectively; TFE^{S}_{Y} is a vector of time fixed-effects that apply to the superstar group ACY^{s} (that is, for each AC cluster in the superstar city, we produce a series of $\hat{P}^{S}_{ACY}$, one for every *Y*); $\hat{\sigma}^{2}_{l}$ is estimated variance of $\varepsilon_{1,j\in l}$ from (2)—the required adjustment in the price projection in (3) and (4) that follows from the logarithmic functional form in (2); and $\hat{\gamma}_1 - \hat{\gamma}_3$ and $\hat{\vec{\gamma}}_4 - \hat{\vec{\gamma}}_5$ are estimated coefficients and vector of coefficients, respectively, that follow from equation (2). That is, based on the estimated coefficients from equation (2) we compute $\hat{P}^{l}_{i\in ACY}$ in (3), the projected price associated with the household *i*'s *actual* housing consumption in city *l*, and $\hat{P}^{S}_{ACY}$ in equation (4), the projected price

[5] In the linear spline regression, we restrict the knots at every room level of the *NR* variable, at every five-floor interval (up to 20 floors) of the *Floor* variable, and at structure age 2, 10, 30, and 70 of the *Age* variable.

[6] Note that, while we observe $NR_{i\in ACY}$ in every *l*, we do not directly observe $CHARACTERISTICS_{i\in ACY}$ in *l* in equation (3). Hence, in our empirical implementation below we proxy $CHARACTERISTICS_{i\in ACY}$ in *l* by a vector of asset characteristic at their average value in *l*.

for household i's consumption-adjusted housing bundle (by household cluster, *ACY*) in the superstar city.[7]

Finally, given a household net (after tax) monthly income, *Income*, we compute:

$$ADS_{i\in ACY}^{l} = \max[(\hat{P}_{ACY}^{S} - \hat{P}_{i\in ACY}^{l})/Income_{i\in ACY}^{l}\ ,1], \quad (5)$$

which we refer to as the Affordability Distance to the Superstar City (ADS) of household *i* in cluster *ACY* and city *l*. In other words, $ADS_{i\in ACY}^{l}$ computes the incremental months of net income required by a household living in city *l* (outside the superstar city) to purchase a standardized home in the adjacent superstar city appropriate to its demographic norm.[8,9]

3. THE SAMPLE

We compute the ADS measure for Tel Aviv, Israel's singular superstar city. The analysis is undertaken using a sample of microdata for more than 235,000 Israeli households. The data include household socio-economic, demographic, locational, and dwelling unit characteristics as provided by the 1998-2011 Combined Household Income and Expenditure Surveys and the 2012-2015 Household Expenditure Surveys conducted by the Israel Central Bureau of Statistics. The annual samples include about 8,000–15,000 observations and are representative of all households in Israel (see Israel Central Bureau of Statistics, 1998–2015). Table 1 shows the annual number of

[7] Note that while we compute the price of the consumption-adjusted bundle by averaging individual room consumption across ACY in the superstar city, one could alternatively average the price of each individual housing consumption bundle in the superstar city. Under Jensen's Inequality, these two approaches are not identical. Importantly, however, our estimation below are robust to this alternative (the average difference in the value of $\hat{P}_{ACY}^{S}$ under the two approaches is 2.9%).

[8] We use $\max(\cdot\,,1)$ on the right-hand side of (3) so as to allow us to apply a logarithmic estimation of *ADS* in what follows [recall that log(1)=0]. Also, while data on mortgage loan-to-value could be incorporated in the computation of $ADS_{i\in ACY}^{l}$, we do not observe information on household mortgage loan. Note, however, that in what follows, we compute aggregate figures of *ADS* across all $i \in ACY$ and *l* and thus, as long as there is no particular pattern in the relationship between *ACY* and LTV, overlooking LTV does not affect the relative outcomes among clusters. Moreover, note that this potential shortcoming applies to other traditional housing affordability measures (e.g., price-to-income ratio).

[9] In an attempt to produce a standardized housing affordability measure along the lines of our suggested procedure, one could have alternatively proposed an estimation equation of the type $NR_{it} = \beta_1 + \beta_2 \times A_{it} + \beta_3 \times C_{it} + \beta_4 \times l_{it} + \varepsilon_{it}$, where *i* and *t* refer to households and time periods (years), respectively; $\beta_1 - \beta_4$ are estimated parameters; ε is a disturbance term; and all other variables are as described above. Note, however, that this equation potentially suffers from endogeneity, as the causality between a household's choice of *C* and *l* and the choice of *NR* may be bi-directional. Our clustering procedure avoids this potential endogeneity problem in estimation.

cross-sectional observations for the 1998–2015 period. Table 2 provides a description and summary statistics of household socio-economic, demographic, locational, and dwelling unit characteristics.

As indicated in Table 2, the typical household in our sample is a homeowner (63 percent) and consists of 1.8 adults and 0.4 children. On average, sampled household heads are 54.6 years old with about 13 years of education. Female-headed households constitute 46 percent of the sample; the majority of sampled households are married (53 percent) whereas 16 percent are single, 11 percent are divorced, and 17 percent are widowed.[10] Israel is a country of immigrants. Household heads by country/continent of origin include Israel (43 percent), Europe or America (19 percent), Asia or Africa (17 percent), and former USSR (21 percent). Finally, the average score on an index of household location among central coastal and hinterland areas is 4.47, where the index ranges from 1 (most peripheral location) to 5 (most central).[11]

Our study employs the universe of all housing transactions in Israeli cities that participate in the Household Income and Expenditure Survey over the 1998–2015 period. Altogether, the Israel Tax Authority recorded over 450,000 transactions in 21 cities.[12] We use this dataset to estimate the house value for each household in the Household Income and Expenditure Surveys. As described above, based on all housing transaction observations, we estimate the hedonic price equation in (2) by which, for each household in the Income and Expenditure surveys, we estimate a house price $\hat{P}_i$ based on attributes of its housing unit (see equation [3]). For each sampled household, we also use this data to estimate the price of the standardized housing consumption bundle of the respective demographic cluster at the superstar city $\hat{P}^S_{ACY}$ (see equation [4]). Table 3 provides a description and summary statistics of dwelling unit characteristics in the housing transaction dataset. As indicated in Table 3, the typical dwelling unit is a 3.5-room condominium apartment located on the second or third floor of a 24-year-old structure. The average unit price is

[10] Household head is generally identified as the person who is the main income provider in the household. See Israel Central Bureau of Statistics (2013) for further details.

[11] The periphery index calculated by the Israel Central Bureau of Statistics is based on a combination of two equally weighted components: an accessibility index (a population-weighted average of distances between a given municipality and all other municipalities in Israel) and a measure of proximity to the Tel Aviv district (see Central Bureau of Statistics, 2008).

[12] The Income and Expenditure Survey does not indicate the type of dwelling unit (whether it is a condominium, detached unit, etc.) in which the household resides. However, as more than 90% of the housing inventory in Israel is condominiums (see Israel Central Bureau of Statistics, 2015), we assume that housing units in the survey are condominiums and thus restrict the transaction dataset (from which a price is matched to the household dwelling in the survey) to include condominium transactions only (we omit about 8.5% non-condominium observations, leaving over 450,000 condominium transaction observations).

about 230,500 dollars, with a standard deviation of about 136,500 dollars (all new Israeli shekel (NIS) figures are translated to US dollars, where 1 US dollar is equal to 4 NIS) [13]

Finally, recall that in the derivation of the ADS measure (section 2), we stratify the sample so as to generate mutually exclusive clusters of households denoted by *ACY*. For a cluster to be included in the estimation, we require at least 10 observations per year and per city over all years. As our ADS measure further relies on the housing consumption in Tel Aviv, we require no less than 500 observations in Tel Aviv for a household cluster (adults and children) to be included in the sample. Table 4 shows the matrix of clusters according to the number of children (*C*) and the number of adults (*A*) and the share of each cluster in the sample. As shown in the table, we observe a sufficient number of households (by number of children and adults) for 6 different clusters. Clusters with 2 adults represent the largest share (60 percent of total households in the sample), whereas clusters comprised of 1 and 3 adults comprise 31 percent and 9 percent of the sample, respectively. Also, 79 percent of households are classified in clusters with no children, followed by clusters with 2 children (9 percent) and a single child (8 percent).

4. CASE STUDY: THE AFFORDABILITY DISTANCE TO TEL AVIV

The focus of our ADS analysis is Tel Aviv. Tel Aviv is located on the Mediterranean coast and is primary among a set of proximate municipalities that house roughly one-half of Israel's population. Tel Aviv's population of about 450,000 persons comprises approximately 5 percent of Israel's population.[14] As regards age structure, Tel Aviv's population is tilted to middle-aged and older age cohorts.[15] Further, a Tel Aviv household is typically smaller than the national average, with 2.3 persons compared with 3.3.[16] While household income in Tel Aviv is slightly higher than the national average, that same metric is a full 40 percent higher than the national when computed by "standardized person", which weighs most heavily the first person in the household and

[13] The number of observations per city ranges from 7,125 to 56,934. Also, the average R^2 of the 21 estimations of equation (2) is equal to 0.82, with a maximum of 0.87 and a minimum of 0.70. Finally, note that out of the total of 76 cities in Israel, we include the 21 cities represented in the clusters generated in section 2 above.

[14] The City of Tel Aviv grew at a damped average annual growth rate of 0.2 percent from 386,000 in 1961 to about 426,000 in 2014. In contrast, Israel's population grew at an annual rate of 2.4 percent to about 8.2 million in 2014.

[15] As of 2014, Tel Aviv was underrepresented among all age cohorts under 24 years of age and overrepresented in the 25-44 and 65+ age groups.

[16] Over 40 percent (Less than 20%) of the households in the city (country) are classified as "non-family" households; whereas about 30% (60%) are family households with children.

gradually less each additional person. The share of households below the poverty line in Tel Aviv is less than half the national average at about 8.6 percent whereas the share of self-employed in Tel Aviv is 18 percent (a full 7 percentage points higher than the national share). About 16 percent of employees in Tel Aviv earn more than twice the national average wage compared with about 10 percent for the nation as a whole.[17] While Tel Aviv comprises 5 percent of the national population, it accounts for over 11 percent of the jobs in Israel, more than twice its share of population. Tel Aviv is home to about one-third of Israel's jobs in financial and insurance; about one-quarter of the national share of jobs in professional, scientific, and technical activities; and about one-fifth of the national jobs in information and communication, entertainment and recreation activities. In sum, Tel Aviv is a vibrant, dominant, and high-income Israeli city characterized by a strong amenity base and a highly-skilled creative class of workers.

4.1 *House Price Returns, Housing Affordability, and Housing Affordability Distance*

Figure 1 plots both nominal quality-adjusted housing price indices (HPIs) and related house price returns for Tel Aviv versus all other cities in Israel over the 1998-2015 period. The quality-adjusted HPIs are estimated using data from the Israel Tax Authority on the universe of all housing transactions in Israel. As is evident, house price movements across locations were similar through 2004 at which point a sharp upswing in the Tel Aviv series commenced. Among other cities in Israel, the upward movement in house prices commenced roughly three years later. Indeed, the figure reveals an elevated rate of house price increase in Tel Aviv over the roughly 2005-2009 period. While house price growth rates among Tel Aviv and other Israeli localities largely converged post-2009, the figure reveals an ever-widening gap in house price index levels between Tel Aviv and other areas. Over the 2005-2015 period, Tel Aviv house values appreciated by 160 percent compared to about 100 percent elsewhere. Figure 2 further shows the dynamic of house prices in different geographic divisions of Israel relative to house prices in Tel Aviv over the past three decades. Results indicate substantial acceleration in quality-adjusted house price returns in Tel Aviv relative to other parts of Israel over much of the 2000s. While Tel Aviv returns reverted to the national mean return by 2011 (as shown in Figure 1), house price index levels for the superstar city remained substantially elevated.

As noted above, the ADS measure addresses potential bias inherent in the housing price-to-income affordability measure as derives from systematic variation across households in

[17] Tel Aviv Statistical Abstract, 2016. Unless specified otherwise, values are for 2015.

preferences for and consumption of housing services. In Israel, the primary metric of housing consumption is total number of rooms in the dwelling unit. Figure 3 plots average number of rooms, NR, consumed by households residing in and outside of Tel Aviv over the 1998–2015 period. As indicated in the chart, housing consumption has gradually increased in the periphery from about 3.1 to over 3.5 rooms per household over the period of analysis while over the same period, consumption in Tel Aviv increased from about 2.8 to below 3.1 rooms per household.

Figure 4 plots the annual average values of the Affordability Distance to the Superstar City (ADS) for Tel Aviv over the 1998-2015 period. The ADS values are presented as both a simple average across all sampled households (and locations) and controlling for household characteristics. An ADS value of about 80 in 1998 (controlling for household characteristics) represents the number of months, on average, of incremental household income required to purchase a quality- and consumption-standardized housing unit in Tel Aviv. As is evident, on net, the affordability distance to Tel Aviv ranges from about 60 to over 100 months of net income over the sample period, suggesting a marked difference in nominal housing affordability in Tel Aviv relative to the broader set of locations beyond the superstar city. The trending up in the affordability distance over the 2007-2015 period roughly coincided with the rate of growth in Tel Aviv house prices (see Figure 1).[18] Further, Figure 5 shows the average ADS for selected adult-children clusters: couples with zero, one, and two children. While the plots show some variance across demographic cohorts over the examined period, they indicate an upward trend in ADS from a level of roughly 50-60 months in 2000 to about 65-85 months in 2015.[19] Moreover, as seen in Figure 6, the run-up in affordability distance to Tel Aviv was most pronounced among cities in Israel's Negev and Galilee periphery as the average peripheral household required an additional 9-14 years of after-tax income to afford a demographically-standardized unit in Tel Aviv over the sample period. As such, results suggest substantial increments in housing affordability barriers to Tel Aviv among peripheral households. As discussed above, we anticipate that barriers associated with affordability distance served to damp household mobility as well as prompt policy actions designed to address state and local efficiency and distributional concerns. Note further that Figure 6 shows affordability distance to Tel Aviv changed less on net over the 1998 – 2015 period among households located in Tel Aviv-proximate areas of central Israel. Those results suggest some

[18] Note that the upward trending ADS over the 2007-2015 period occurred despite the increased gap in demographically-adjusted housing consumption between the periphery and Tel Aviv.

[19] The largest increment in average ADS is experienced among households consisting of one adult with no children (not plotted in Figure 5 and is available upon request).

equilibration in housing market dynamics among Tel Aviv and adjacent suburbs over the sample period.

4.2 *Physical Distance and Affordability Distance*

We further evaluate the association between physical and affordable distance to Tel Aviv. Figure 7 displays the 2015 median house price per square-meter as a function of the geographic distance to Tel Aviv (a zero-kilometer distance represents the City of Tel Aviv itself). As expected, prices generally decline with physical distance from Tel Aviv. The median price per square-meter does turn up some in Jerusalem at a distance of about 50 kms from Tel Aviv. That notwithstanding, the median price per square meter in Jerusalem remains far below that of Tel Aviv.[20] The figure further indicates a Tel Aviv-to-other city price ratio in the range of 2–4 at distances of 20km and beyond. We also regress the ADS measure on the geographic distance to Tel Aviv as measured in kilometers. Figure 8 plots the affordability distance slope with respect to physical distance by year for the 1998-2015 period for two different model specifications. The solid line derives from a city/year balanced panel of all cities continuously represented in our sample. In each year, we run a separate cross-sectional (cross-city) regression of average ADS of households in city l on distance in kilometers to Tel Aviv. The solid line plots the estimated coefficient on distance for each survey year. As changes in the characteristics of sampled city households may introduce bias into this model, we estimate a second pooled model using micro data, whereby we interact each household's distance to Tel Aviv with a categorical term for each survey year, controlling for household composition. The scattered line is the estimated coefficient of the year-specific distance term in that second model. Results of the aggregate city-level cross-sectional model suggest that each kilometer increment in geographical distance to Tel Aviv translates into an average 1.2 – 2.2 months of additional income required by the household to purchase a consumption-adjusted home in Tel Aviv. The controlled micro-level estimation suggests that 0.5 – 1.4 additional months of income are required. Both analyses indicate similar trends in the effects of physical distance on affordability distance. Most strikingly, while an incremental kilometer of physical distance was associated with 0.6 additional months of net income in 2000, roughly 1.4 additional months of net income are required per kilometer by 2015.

[20] Jerusalem is the capital of Israel and its largest city, with about 865,000 residents (about twice of Tel Aviv) as of 2015. Tel Aviv, however, is de-facto the economic capital of the country, as reflected by the statistics presented above.

4.3 *Inequality in Housing Affordability*

We also examine inequality in housing affordability distance among sampled households. Figure 9 depicts the ratios $NR_{ACY}^{S}/NR_{i\in ACY}^{l}$ and $\hat{P}_{ACY}^{S}/\hat{P}_{i\in ACY}^{l}$ by income deciles for 2015. Among lower-income deciles, $NR_{ACY}^{S}/NR_{i\in ACY}^{l}$ is greater than 1, implying that despite the fact that those households live in relatively inexpensive housing units in the periphery, their consumption of housing is below that of corresponding (demographically-matched) households in Tel Aviv. In contrast, $NR_{ACY}^{S}/NR_{i\in ACY}^{l}$ is less than 1 for the higher-income deciles, indicating damped housing consumption among the wealthy in Tel Aviv relative to peripheral areas. Also, $\hat{P}_{ACY}^{S}/\hat{P}_{i\in ACY}^{l}$ is greater than 1 (and substantially greater than $NR_{ACY}^{S}/NR_{i\in ACY}^{l}$) for all income deciles, reflecting the much higher housing prices in Tel Aviv as compared to the periphery.

Figure 10 shows the average ADS by income deciles in 2015. The decline of ADS with income, particularly for the lower income deciles, indicates a considerable inequality among households measured by ADS. Below we follow recent studies by Ben-Shahar and Warszawski (2016) and Ben-Shahar, Gabriel, and Golan (2017), who extend the Gini measure to capture housing affordability inequality. Recall that the Gini coefficient is commonly used to measure income inequality and has been extended to estimate inequality in multiple other economic dimensions.[21] As the Gini is designed for desirable goods, while housing affordability measures affordability distress, we calculate housing affordability inequality by applying the Gini on the inverse value of housing affordability. We thus per equation (5) assign each household a $1/ADS_{i\in ACY}^{l}$ value [i.e., $Income_{i\in ACY}^{l}/(\hat{P}_{ACY}^{S}-\hat{P}_{i\in ACY}^{l})$] and compute the Gini coefficient for every year in the sample. For comparison, we also compute income-to-housing price (i.e., 1/price-to-income) and income Gini indices. Figure 11 plots the annual Gini coefficients for the affordability distance measure, the traditional housing affordability measure (1/price-to-income), and household income for the 1998-2015 period. As indicated, at about 0.35, the Gini coefficient associated with traditional housing affordability is of roughly the same magnitude as that of income inequality. Inequality in affordability distance to Tel Aviv, however, is substantially higher at about 0.8. Further, while the Gini on income inequality trends down slightly over the period of analysis, such

[21] For income, the Gini measure accumulates, for each income level, the difference between the share of total income earned by individuals at this income level or below it and the share of those individuals in the population. For a population with non-negative income values, it ranges from 0, which implies perfect equality, to 1, which implies that all the populations' income is earned by a fraction of the population (among the many applications see, for example, Alderson and Nielsen, 2002; Leigh, 2007; and Frank, 2009). Also, see extension of the Gini coefficient approach for measuring, for example, inequality in education and human capital inequality (Földvári and Leeuwen, 2011), fossil resource consumption (Papathanasopoulou and Jackson, 2009), ecological entitlements (Ruitebeek, 1996), and child achievements (Sastry and Pebley, 2010).

a trend is not evidenced in the housing measures. In sum, while results suggest sizable income and housing affordability inequality in Israel, distributional concerns are substantially heightened as regards affordability distance to Tel Aviv. Indeed, the latter metric suggests elevated inequality in popular access and affordability distance to Tel Aviv.

4.4 *Household Characteristics and Housing Affordability Distance*

Finally, we evaluate the association between household characteristics and housing affordability distance.

Consider the following equation

$$\ln(ADS^{l}_{i\in ACY}) = \theta_1 + \vec{\theta}_2 HHCharacteristics^{l}_{i\in ACY} + \vec{\theta}_3 LFE_l + \vec{\theta}_4 TFE + \varepsilon_{2i}, \qquad (6)$$

where $ADS^{l}_{i\in ACY}$ is, once again, the ADS measure for household *i* in city *l*. Also, $HHCharacteristics_i$ is a vector of householder characteristics including his/her age, gender, nationality, ethnic origin, and education (see, once again, variable description in Table 2); *TFE* is a vector of time (year) fixed-effects, θ_1 and $\vec{\theta}_2 - \vec{\theta}_4$ are estimated coefficient and vector of coefficients, respectively, ε_2 is a random disturbance term, and all other variables are as described above.

Table 5 present results of estimation of equation (6) for the ADS measure. Results indicate the associations between household characteristics and affordability distance. Specifically, every additional year of education is associated with a 8.7 percent decrease in ADS (significant at the 1% level); compared to married households, single divorced, and widowed household-heads are associated with 48, 25, and 11 percent increase in ADS, respectively (significant at the 1% level); female-headed households are marginally significantly associated with 2 percent increase in ADS; and, finally, compared to Israeli born household-heads whose father's origin is Israel, Israeli born household-heads whose father's origin is Asia or Africa, Europe or America, and former USSR are associated with 12, 44, and 42 percent decrease in ADS, respectively (significant at the 1% level), while household-heads born in Asia or Africa, Europe or America, and former USSR are associated with 10 and 13 percent decrease and 49 percent increase in ADS, respectively (significant at the 1% level). In sum, as would be expected, results suggest lower affordability distance to Tel Aviv among more highly educated, married, and non-immigrant populations.

5. ON THE ASSOCIATION BETWEEN AFFORDABILITY DISTANCE, MIGRATION, AND GOVERNMENT POLICY

In this section, we evaluate the role of affordability distance as a driver of inter-urban population flows. Further, per discussion above we evaluate the efficacy of government policy interventions seeking to mediate the affordability distance between Tel Aviv and surrounding areas.

5.1 *ADS and Migration*

Consider the following estimated model:

$$\ln(ADS_{i\in ACY}^{S\to l}) = \delta_{0,l} + \vec{\delta}_{1,l} HHCharacteristics_{i\in ACY}^{S} + \vec{\delta}_{2,l} Policy_{Y} + \varepsilon_{3,i\in ACY}^{S\to l} \text{ for all } l \tag{7}$$

and

$$OutMig_{l,Y} = \beta_0 + \beta_1 \overline{\widehat{ADS}}_{Y}^{S\to l} + \beta_2 Trend_Y + \vec{\beta}_3 LFE_l + \varepsilon_{4,l,Y}, \tag{8}$$

where equation (8) estimates out-migration from the superstar city (Tel Aviv) and equation (7) is an auxiliary equation whose objective is to address the possible endogeneity between out-migration and ADS as further explained below. Also, i, l, and Y represent households, cities (other than Tel Aviv), and time periods (years), respectively; $ADS_{i\in ACY}^{S\to l}$, the dependent variable in (7), is household i's vector of affordability distance measures *from* the superstar city (Tel Aviv) *to* a non-superstar city l (i.e., a series of l measures for each i in S—one for each city l). That is, along the lines of the derivation of $ADS_{i\in ACY}^{l}$ in equations (1)-(5), we have $ADS_{i\in ACY}^{S\to l} = \max[(\hat{P}_{i\in ACY}^{S} - \hat{P}_{ACY}^{l})/Income_{i\in ACY}^{S}, 1]$, where $\hat{P}_{i\in ACY}^{S}$ is a hedonic price that is matched to household i's actual housing consumption in the superstar city (S); $\hat{P}_{ACY}^{l}$ is a hedonic price of the standardized (demographically- and time-matched) housing unit in city l; and $Income_{i\in ACY}^{S}$ is the net income of household i in S (see detailed derivation of $ADS_{i\in ACY}^{S\to l}$ in the appendix). The independent variables in (7) include $HH\_Characteristics_{i\in ACY}^{S}$, a vector of household characteristics, including *Age, Status* dummies, *Female*, *Education*, and *Continent* dummies (see Table 2); $Policy_Y$, a vector of policy related time series variables, including $TransInv_{Y-3}$, 3-year lagged government spending on transportation infrastructure (measured in percentage of GDP); $StartsTA_{Y-2}$, 2-year lagged housing unit construction starts in Tel Aviv (in thousands of units); $Starts20km_{Y-2}$, 2-year lagged housing unit construction starts up to 20 kilometers away from Tel Aviv (in thousands of units); and $MortRate_Y$, average mortgage rate. Also, *LFE* is a vector of location (city l) fixed-effects, $\ln(\cdot)$ is a log operator,

δ_0 and $\vec{\delta}_1 - \vec{\delta}_3$ are estimated parameters and vectors of parameters, respectively, and ε_3 is a random disturbance term (see list of variables, description, and related summary statistics in Table 6).

The dependent variable in (8) is $OutMig_{l,Y}$, the total number of households who migrate from the superstar city (Tel Aviv) to city l at year Y and the independent variables in (8) include $\overline{\widehat{ADS}}_Y^{S\rightarrow l}$, the average projected value of $ADS_{i\in ACY}^{S\rightarrow l}$ that follows from the estimation of equation (7) across all $i \in ACY^S$ for all *l*; and $Trend_Y$, a time-trend variable. Also, $\beta_0 - \beta_2$, and $\vec{\beta}_3$ are estimated parameter and vectors of parameters, respectively, and ε_4 is a random disturbance terms. All other variables and notations are as described above.[22]

In equation (8), we estimate the association between out-migration from the superstar city (Tel Aviv) and housing affordability distance, measured as the gain (in months of net income) that households living in the superstar city generate by migrating to a quality- and consumption-adjusted housing unit in any city *l* (other than the superstar city). Hence, equation (8) is estimated as a panel of cities *l* over the period 1998-2014. However, due to potential endogeneity between out-migration from the superstar city ($OutMig$) and ADS, we use (7) as an auxiliary equation, where the average of the projection of $ADS_{i\in ACY}^{S\rightarrow l}$ (average over all *i* in *S* at time *Y*) from (7) is computed for all *l*, generating $\overline{\widehat{ADS}}_Y^{S\rightarrow l}$ to be substituted on the right-hand side of (8).[23] Note that under this formulation, equations (7) and (8) are estimated as a 2SLS type model where (8) is estimated in a (city-*l*) panel structure.

Column 1 in Table 7 present the results of the city-panel estimation of equation (8). As could be seen, these results suggest a positive association between $\overline{\widehat{ADS}}_Y^{S\rightarrow l}$ and out-migration from Tel Aviv. In particular, the results imply that an increase in $\overline{\widehat{ADS}}_Y^{S\rightarrow l}$ by 10 months (of net income) is associated with increased household out-migration from the superstar city by about 6 percent (of the average out-migration level; significant at the 5% level).[24] Column 2 in Table 7 examines the robustness of the results to a population normalized, rather than nominal measurement of out-migration. Specifically, we replace the dependent variable in (8) with $OutMig_{l,Y}/CityPop_{l,Y}$, total

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[22] Data on the $OutMig$ variable is available to us from the Israel Central Bureau of Statistics for the period 1998-2014.

[23] See summary statistics of $\overline{\widehat{ADS}}_Y^{S\rightarrow l}$ in Table 6.

[24] As noted, the average of $OutMig_{l,Y}$ is about 11.3 per city/year; hence the coefficient of 0.067 on the $\overline{\widehat{ADS}}_Y^{S\rightarrow l}$ variable is translated to about 6 percent increase in the average out-migration that is associated with every 10 months increase in $\overline{\widehat{ADS}}_Y^{S\rightarrow l}$.

out-migration from *S* to *l* in year *Y* divided by the population of *l* in year *Y*. As can be seen, the results are robust to this specification; 10 additional months of $\overline{\widehat{ADS}}_Y^{S\rightarrow l}$ are associated with about 7 percent increase (of the average standardized out-migration level; significant at the 1% level) in out-migration from the superstar city.[25] Overall, findings indicate the salience of affordability distance to Tel Aviv inter-city population flows.

5.2 *Government Policy and ADS*

Consider the following estimated equation:

$$\ln(ADS_{i\in ACY}^{l}) = \alpha_0 + \vec{\alpha}_1 HH\_CHARACTERISTICS_{i\in ACY}^{l} + \vec{\alpha}_2 POLICY_Y + \vec{\alpha}_3 LFE_l + \varepsilon_{5,i\in ACY}^{l} \quad (9)$$

where the indices *i* and *l* in (9) are once again households and cities (other than Tel Aviv), respectively, and *Y* is the time (year) when the household is observed. The dependent variable, $ADS_{i\in ACY}^{l}$, is the individual household affordability distance to Tel Aviv measure from equation (5). Also, α_0 and $\vec{\alpha}_1 - \vec{\alpha}_3$ are estimated parameters and vectors of parameters, respectively; ε_5 is a random disturbance term; and all other variables are as discussed above.

The formulation of equation (9) allows us to estimate the association between ADS and government policy measures to increase job access to and affordability of housing in Tel Aviv. Per above, those interventions included programs to increase Tel Aviv housing supply as well as government investment in inter-city transportation networks including development of highways and fixed rail. Column 1 in Table 8 presents the estimation results for the full sample. Results with regards to policy measures suggest that construction of 100 housing units in Tel Aviv is associated with a 0.7% percent decrease in the *ADS* (significant at 1% level). Results further show that government spending on transportation infrastructure is associated with a decrease in the *ADS*. Specifically, every 1 percentage point of GDP invested in transportation infrastructure is associated with about a 35 percent decrease in *ADS* (significant at 1% level).[26]

Column 2 (3) in Table 8 presents the estimation results for the sub-sample of households who reside up to (in excess of) 20 kilometers from Tel Aviv. These results shed light on the

[25] The average of $OutMig_{l,Y}/CityPop_{l,Y}$ is about 0.1 per city/year; hence the coefficient of 0.00077 on the $\widehat{ADS}_{l,Y}^{S}$ variable is translated to about 7 percent increase in the average $OutMig_{l,Y}/CityPop_{l,Y}$ that is associated with every 10 months increase in $\widehat{ADS}_{l,Y}^{S}$

[26] Among other controls, the mortgage interest rate is negatively associated with *ADS*, where each percentage point increase in mortgage rate is associated with about 6% decrease in *ADS* (significant at 1% level).

association between government transportation infrastructure investment and the *ADS* for cities immediately proximate to (distant from) Tel Aviv. Specifically, every additional 1 percentage point of GDP invested in transportation infrastructure is associated with a decrease of about 19 and 48 percent in the *ADS* measure in cities adjacent to Tel Aviv and peripheral cities, respectively (significant at 1% level). Indeed, transportation infrastructure investment facilitates commutes and enhances the substitutability of housing in outlying areas to that of Tel Aviv. In so doing, such investment serves to arbitrage differentials in house prices and employment opportunity between Tel Aviv and peripheral areas so as to reduce the ADS. Finally, results suggest a diminishing association between new housing construction in Tel Aviv and ADS for households living farther away from Tel Aviv.

6. SUMMARY AND CONCLUSIONS

This study introduces a measure of affordability distance to a superstar city. Affordability distance is defined in terms of incremental household income required to consume a quality- and consumption-adjusted housing unit in the proximate superstar city. Concerns regarding affordability declines and related access to superstar cities have become both widespread and acute over the course of recent years. Under certain circumstances, elevated affordability distance may damp net migration to superstar locations as well as spur government interventions seeking to address related distributional and efficiency concerns.

The analysis focuses on Tel Aviv, a city known for its unique amenities, constrained land supply, tech agglomeration, and elevated house price growth. Affordability distance to Tel Aviv rose by roughly 60 percent over the 2000 – 2015 period. The run-up in affordability distance to Tel Aviv was most pronounced among cities in Israel's Negev and Galilee periphery as the average household in those areas required an additional 9-14 years of after-tax income to afford a demographically-standardized unit in Tel Aviv. Affordability distance was particularly elevated among non-married, lower educational attainment, and immigrant households.

Estimation findings provide new insight as to the consequences of elevated affordability distance to Tel Aviv. As anticipated, the upward movement in affordability distance was associated with increased migration from the city. Analysis of panel data suggests that interventions including regional transportation infrastructure investment and increments to local housing supply may be effective in mediating affordability distance.

References

Alfasi, N., and T. Fenster (2005). A tale of two cities: Jerusalem and Tel Aviv in an age of globalization. Cities, 22(5):351-363.

Alderson, A. S., and Nielsen, F. (2002). Globalization and the great U-turn: Income inequality trends in 16 OECD countries. *American Journal of Sociology*, 107(5), 1244–1299.

Awan, K., Odling-Smee, J.C. and Whitehead, C. (1982). Household attributes and the demand for private rental housing, *Economica*, 49(194):183–200.

Belsky, E., Goodman, J. and Drew, R. (2005). *Measuring the nation's rental housing affordability problems*, Cambridge, MA: Joint Center for Housing Research, Harvard University.

Ben-Shahar, D., S. Gabriel, and R. Golan, (2017). Housing affordability and inequality: A consumption-adjusted approach. Working paper.

Ben-Shahar, D. and Warszawski, J. (2016). Inequality in housing affordability: measurement and estimation. *Urban Studies*, 53(6):1178-1202.

Birch, E. L. (Ed.). (1985). The unsheltered woman: women and housing in the 80s. *Center for Urban Policy Research.*

Bogdon, Amy S. and Can, Ayse (1997). Indicators of local housing affordability: comparative and spatial approaches, *Real Estate Economics*, 25(1):43–80.

Bratt, Rachel G., Stone, Michael E. and Hartman, Chester (2006). A right for housing: foundation for a new social agenda, *Temple University Press*.

Brounen, D., Neuteboom, P. and van Dijkhuizen, A. (2006). House prices and affordability: a first and second look across countries, *De Nederlandsche Bank Working Paper #83.*

Cancian, M., and Reed, D. (1998). Assessing the effects of wives' earnings on family income inequality. *Review of Economics and Statistics*, 80(1), 73–79.

Charlier, E., Melenberg, B., & van Soest, A. (2001). An analysis of housing expenditure using semiparametric models and panel data. *Journal of Econometrics*, 101(1), 71–107.

Chen, Jie, Hao, Qianjin and Stephens, Mark (2010), Assessing housing affordability in post-reform China: a case study of Shanghai, *Housing Studies*, 25(6):877–901.

Engelhardt, G. V., & Poterba, J. M. (1991). House prices and demographic change: Canadian evidence. *Regional Science and Urban Economics*, 21(4), 539–546.

Földvári, P., and van Leeuwen, B. (2011). Should less inequality in education lead to a more equal income distribution? *Education Economics*, 19(5), 537–554.

Fortin, M., & Leclerc, A. (2000). Demographic changes and real housing prices in Canada. Canada Mortgage and Housing Corporation.

Frank, M. W. (2009). Inequality and growth in the United States: Evidence from a new state-level panel of income inequality measures. *Economic Inquiry*, 47(1), 55–68.

Fraser, Ian (1998). *Hegel and Marx and the concept of need*, Edinburgh University Press.

Gan, Quan and Hill, Robert J. (2009). Measuring housing affordability: looking beyond the median, *Journal of Housing Economics*, 18(2):115–125.

Goodman, Allen C. (1990). Demographics of individual housing demand, *Regional Science and Urban Economics*, 20(83–102).

Green, R., & Hendershott, P. H. (1996). Age, housing demand, and real house prices. *Regional Science and Urban Economics*, 26(5), 465–480.

Gyourko, Joseph and Linneman, Peter (1993). The affordability of the American dream: an examination of the last 30 years, *Journal of Housing Research* 4(1).

Gyourko, J. and Tracy, J (1999). A look at real housing prices and incomes: some implications for housing affordability and quality, *Federal Reserve Bank of New York Economic Policy Review*, 5:63–77.

Haffner, M., & Heylen, K. (2011). User costs and housing expenses. Towards a more comprehensive approach to affordability. *Housing Studies*, 26(04), 593–614.

Hendershott, Patric H. (1980). Real user costs and the demand for single–family housing, *Brookings Papers Econ. Activity*, 2:401–44.

Hirayama, Y. (2010). Housing pathway divergence in Japan's insecure economy. *Housing Studies*, 25(6), 777–797.

Hulchanski, J. D. (1995). The concept of housing affordability: six contemporary uses of the housing expenditure-to-income ratio, *Housing Studies* 10(4):471–491.

Israel Central Bureau of Statistics (1998–2013). *Statistical Abstract of Israel*, publication number 42-64, Jerusalem, Israel

Israel Central Bureau of Statistics (1991–2013). *Household Expenditure and Income Surveys*. Jerusalem, Israel.

Israel Central Bureau of Statistics (2013a). *Income Survey 2011*, publication number 1524, Jerusalem, Israel.

Israel Central Bureau of Statistics (2013b). Characterization and Classification of Geographical Units by the Socio-Economic level of the Population 2008. *Publication number 1530*, Jerusalem, Israel.

Israel Central Bureau of Statistics (2008). Peripherality index of local authorities 2004—new development. *Press Release*, Jerusalem, Israel.

Jones, Lawrence (1989). Current wealth and tenure choice, *Journal of the American Real Estate and Urban Economics Association*, 17:7–40.

Kim, K. H., & Cho, M. (2010). Structural changes, housing price dynamics and housing affordability in Korea. *Housing Studies*, 25(6), 839–856.

Kutty, N. K. (2005). A new measure of housing affordability: estimates and analytical results. *Housing policy debate*, 16(1), 113–142.

Laux, S. C., and Cook, C. C. (1994). Female-headed households in nonmetropolitan areas: Housing and demographic characteristics. *Journal of Family and Economic Issues* 15.4: 301–316.

Leigh, A. (2007). How closely do top income shares track other measures of inequality? *Economic Journal*, 117, F589–F603.

Lerman, Donald L. and Reeder, William J. (1987). The affordability of adequate housing, *Real Estate Economics*, 15(4):389–404.

Li, Henry (2014). The effects of demographics on the real estate market in the United States and China. *Honors College Theses*. Paper 137.

Lin, Y. J., Chang, C. O., & Chen, C. L. (2014). Why homebuyers have a high housing affordability problem: Quantile regression analysis. *Habitat International*, 43, 41–47.

Malpezzi, S. (1999). A simple error correction model of house prices, *Journal of Housing Economics*, 8:27–62.

Mankiw, N. G., & Weil, D. N. (1989). The baby boom, the baby bust, and the housing market. *Regional science and urban economics*, 19(2), 235–258.

Mayer, Christopher J. and Engelhardt, Gary V. (1996). Gifts, down payments, and housing affordability, *Journal of Housing Research* 7(1):59–77.

Mayo, Stephen K. (1981), Theory and estimation in the economics of housing demand, *Journal of Urban Economics*, 10:95–116.

Miron, J. R (1985). Housing affordability and willingness to pay, report submitted to the Canada Mortgage Corporation.

Myers, D., & Vidaurri, L. (1996). Real demographics of housing demand in the United States. *The Lusk Review for Real Estate Development and Urban Transformation*, 2(1), 55–61.

Norris, Michelle and Shiels, Patrick (2007). Housing affordability in the Republic of Ireland: is planning part of the problem or part of the solution?, *Housing Studies*, 22(1):45– 62.

Ohtake, F., & Shintani, M. (1996). The effect of demographics on the Japanese housing market. *Regional Science and Urban Economics*, 26(2), 189–201.

Ong, S. E. (2000). Housing affordability and upward mobility from public to private housing in Singapore, *International Real Estate Review*, 3(1):49–64.

Papathanasopoulou, E., and Jackson, T. (2009). Measuring fossil resource inequality—A case study for the UK between 1968 and 2000. *Ecological Economics*, 68(4), 1213–1225.

Pitkin, J. R., & Myers, D. (1994). The specification of demographic effects on housing demand: avoiding the age-cohort fallacy. *Journal of Housing Economics*, 3(3), 240–250.

Quigley, John M. and Raphael, S. (2004). Is housing unaffordable? Why isn’t it more affordable?, *Journal of Economic Perspectives*, 18(1):129–152.

Reed, R. (2002). The importance of demography in the analysis of residential housing markets, AsRES/AREUEA Joint International Conference.

Robert, Peter (1997). Social determination of living conditions in post-communist societies, *Czech Sociological Review*, 5(2):197–216.

Robinson, Mark, Scobie, Grant M. and Hallinan, Brian (2006), Affordability of housing: concepts, measurement and evidence, New Zealand Treasury Working Paper 06/03.

Saegert, Susan and Clark, Helene (2006). *Opening doors: what right to housing means for woman, in a right for housing*, Philadelphia: Temple University Press.

Sastry, N., and Pebley, R. (2010) Family and neighborhood sources of socioeconomic inequality in children’s achievement. *Demography*, 47(3), 777–800.

Seek, N.H. (1983). Adjusting housing consumption: improve or move, *Urban Studies*, 20:455–469.

Skaburskis, A. (1997). Gender differences in housing demand. *Urban Studies*, 34(2), 275–320.

Skaburskis, A. (2004). Decomposing Canada's growing housing affordability problem: do city differences matter?, *Urban Studies*, 41(1), 117–149.

Smets, Peer (1999). Housing finance trapped in a dilemma of perceptions: affordability criteria for the urban poor in India questioned, *Housing Studies*, 14(6):821–838.

Stone, Michael E. (2006). What is housing affordability? The case for the residual income approach, *Housing Policy Debate* 17(1), 151–184.

Swan, C. (1995). Demography and the demand for housing: a reinterpretation of the Mankiw-Weil demand variable. *Regional Science and Urban Economics*, 25(1), 41–58.

Thalmann, P. (1999). Identifying households which need housing assistance, *Urban Studies*, 36(11):1933–1947.

Weicher, John (1977). The affordability of new homes, *American Real Estate and Urban Economics Association*, 7:40–51.

Whitehead, C. (1991). From need to affordability, *Urban Studies*, 28(6):871–887.

Table 1: Number of Cross-Sectional Annual Observations for the 1998–2015 Period

Year	Source	Number of Observations (households in survey)	
		Raw sample	Clean Sample
1998	Household Income and Expenditure Survey	13,499	5,149
1999		13,515	5,050
2000		13,485	5,070
2001		13,689	5,058
2002		14,201	5,198
2003		14,418	5,113
2004		14,636	5,248
2005		14,545	5,218
2006		14,582	5,391
2007		14,147	5,130
2008		14,167	5,094
2009		15,114	5,560
2010		15,171	5,435
2011		14,996	5,359
2012	Household Expenditure Survey	8,742	3,050
2013		9,507	3,306
2014		8,465	2,921
2015		8,550	2,849
Total		235,429	85,199

Notes: Observations indicated in Table 1 come from the Household Income and Expenditure Surveys and the Household Expenditure Survey, both conducted by the Israel Central Bureau of Statistics. We use the Household Expenditure Survey subsequent to 2011 because the way income is measured in the combined Household Income and Expenditure Survey in those years is inconsistent with the pre-2011 definition. Original total number of households in the sample is 235,429. Missing observations, observations of households living in cities with insufficient number of housing transactions or insufficient number of similar household compositions at the city level (in terms of number of adults and number of children), and the omission of outliers in terms of income or housing unit size, led to a final sample of 85,199 households for the ADS measure.

Table 2: List of Variables from Income and Expenditure Surveys, Definitions, and Summary Statistics

Variable	**Definition**	**Mean**	**Std. Dev.**	**Min**	**Max**
Adults	Number of adults in household	1.777	0.588	1	3
Children	Number of children (under 18) in household	0.392	0.830	0	3
Periphery	Score on the peripheral index (ranges from 1 [most peripheral] to 5 [most central])	4.472	0.863	2	5
Income	Household monthly net income (in dollars)	9,110	6,684	750	40,243
$NR_{i \in ACY}^{l}$	Actual number of rooms consumed by a household in city *l*	3.22	1.05	1.0	7.0
NR_{ACY}^{S}	Standardized number of rooms in Tel Aviv	3.01	0.42	2.48	3.83
$\hat{P}_{i \in ACY}^{l}$	Estimated price of the actual dwelling unit consumed by a household (in dollars)	200,138	107,774	20,431	1,050,295
$\hat{P}_{ACY}^{S}$	Estimated price of the standardized dwelling unit in the superstar city (in dollars)	291,200	93,515	172,993	595,112
Tenure	Dummy variable that equals 1 if household is a homeowner and 0 otherwise	0.631	0.482	0	1
Education	Number of Years of education (truncated at 22)	13.03	4.33	0	22
Female	Household head is female	0.457	0.498	0	1
Age	Household head age	54.6	19.4	16	108
Married	Household family status: Married	0.529	0.499	0	1
Single	Household family status: Single	0.157	0.364	0	1
Divorced	Household family status: Divorced	0.111	0.314	0	1
Widowed	Household family status: Widowed	0.174	0.379	0	1
Separated	Household family status: Living separately	0.015	0.122	0	1

Table 2 (Cont.): List of Variables from Income and Expenditure Surveys, Definitions, and Summary Statistics

Variable	Definition	Mean	Std. Dev.	Min	Max
Israel/Israel	Household head born in Israel and father is either born in Israel or unknown	0.144	0.351	0	1
Israel/ Asia_Africa	Household head is born in Israel and father's continent of origin is Asia or Africa	0.140	0.346	0	1
Israel/ Euro_America	Household head born in Israel and father's continent of origin is Europe or America	0.124	0.329	0	1
Israel/USSR	Household head born in Israel and father's origin is former USSR	0.020	0.138	0	1
Asia_Africa	Household head continent of origin is Asia or Africa	0.169	0.375	0	1
Euro_America	Household head continent of origin is Europe or America	0.193	0.395	0	1
USSR	Household head origin is former USSR	0.212	0.409	0	1

Table 3: List of Variables in the Housing Transactions Recorded by the Israel Tax Authority, Description, and Summary Statistics

Variable	Description	Avg.	Std.	Min	Max
P	Transaction closing price (in dollars)	230,512	136,445	23,012	1,617,458
Room	Total number of rooms	3.491	0.882	2	5
Age	The age of the structure (in years) at the time of the transaction	23.595	18.760	1	100
Story	The story on which the asset is located in the structure	2.908	3.070	0	40
DumNew	Dummy variable that equals 1 if *Age* is no more than 1 year; 0 otherwise	0.171	0.376	0	1

Table 4: Household Clusters According to Number of Children and Number of Adults and Their Share in the Sample

	1 Adult	**2 Adults**	**3 Adults**	**Total**
No Children	31.0%	39.5%	8.6%	79.1%
1 Child		7.7%		7.7%
2 Children		8.7%		8.7%
3 Children		4.5%		4.5%
Total	31.0%	60.4%	8.6%	100.0%

Notes: Cells representing clusters of households with insufficient number of observations are left blank (as we condition the inclusion of a cluster in a given year by including no less than 10 households in each city). Households in these clusters in cities that do not meet this condition for all of the sample years are omitted from the sample. As a result, the attained cluster distribution, while resembling that of the general population, exhibits a slight bias toward the larger clusters. The maximum bias is attained for the 2-person households whose share in the population (sample) equals 25% (39.3%).

Table 5: Population Characteristics and Distance from Tel Aviv

Variable	ln(ADS)	ADS
Column	(1)	(2)
Constant	3.197***	68.72***
	[0.0341]	[1.767]
Female	0.0170*	1.289**
	[0.0100]	[0.521]
Education	-0.0873***	-3.547***
	[0.00123]	[0.0638]
Age	-0.00817***	-0.0489***
	[0.000333]	[0.0173]
Single	0.482***	32.11***
	[0.0143]	[0.743]
Divorced	0.257***	23.44***
	[0.0153]	[0.794]
Widowed	0.116***	16.60***
	[0.0152]	[0.788]
Separated	0.218***	19.68***
	[0.0368]	[1.907]
Israel/Asia_Africa	-0.119***	-12.50***
	[0.0172]	[0.893]
Israel/Euro_America	-0.441***	-18.63***
	[0.0179]	[0.930]
Israel/USSR	-0.424***	-18.13***
	[0.0349]	[1.808]
Asia_Africa	-0.103***	-10.34***
	[0.0186]	[0.963]
Euro_America	-0.128***	-14.98***
	[0.0178]	[0.924]
USSR	0.489***	15.92***
	[0.0168]	[0.871]
LFE (city fixed effects)	included	included
TFE (time fixed effects)	included	included
N	82,305	82,305
R^2	0.458	0.317

Table 6: Summary Information for Estimation of Equations (7) and (8)

Variable	**Description**	**Avg.**	**Std.**	**Min**	**Max**
$OutMig_{l,Y}$	Number of households who out-migrate from the superstar city (Tel Aviv) to city *l* in year *Y* (in thousands)	11.374	11.497	0	55
$\frac{OutMig_{l,Y}}{CityPop_{l,Y}}$	Number of households who out-migrate from the superstar city (Tel Aviv) to city *l* in year *Y* divided by city *l*'s population in *Y*	0.103	0.126	0	0.842
$\overline{\widehat{ADS}}_Y^{S\to l}$	the average projected value of $ADS_{i\in ACY}^{S\to l}$ that follows from the estimation of equation (7) across all $i \in ACY^S$ for all l	61.980	39.537	-15.3	154.2
$TransInv_{Y-3}$	government spending on transportation infrastructure (measured in percentage of GDP)	0.879	0.149	0.7	1.2
$StratsTA_{Y-2}$	housing unit construction starts in Tel Aviv (in thousands)	1.857	0.665	0.895	3.721
$Strats20km_{Y-2}$	housing unit construction starts up to 20 km away from Tel Aviv (in thousands)	8.624	1.588	6.709	12.110
$MortRate_Y$	average mortgage rate (in percentage points)	4.861	1.378	2.350	6.848

Notes: Data on $OutMig_{l,Y}$, $CityPop_{l,Y}$, $TransInv_{Y-3}$, $StratsTA_{Y-2}$, and $Strats20km_{Y-2}$ is provided by the Israel Central Bureau of Statistics; data on $MortRate_Y$ is provided by the Bank of Israel and $\widehat{ADS}_{l,Y}^S$ is generated by equation (7).

Table 7: Effects of Affordability Distance on Migration

Variable	Dependent Variable: $OutMig_{l,Y}$	Dependent Variable: $OutMig_{l,Y}/CityPop_{l,Y}$
Column	(1)	(2)
Constant	1142.1*** [189.3]	12.03*** [1.928]
$\overline{\widehat{ADS}}_{Y}^{S\to l}$	0.0672** [0.0279]	0.000767*** [0.000288]
Trend	-0.566*** [0.0948]	-0.00597*** [0.000965]
LFE	Included	Included
N	280	280
# of cities	20	20
R^2 (overall)	0.122	0.139
Prob(F>0)	0	0

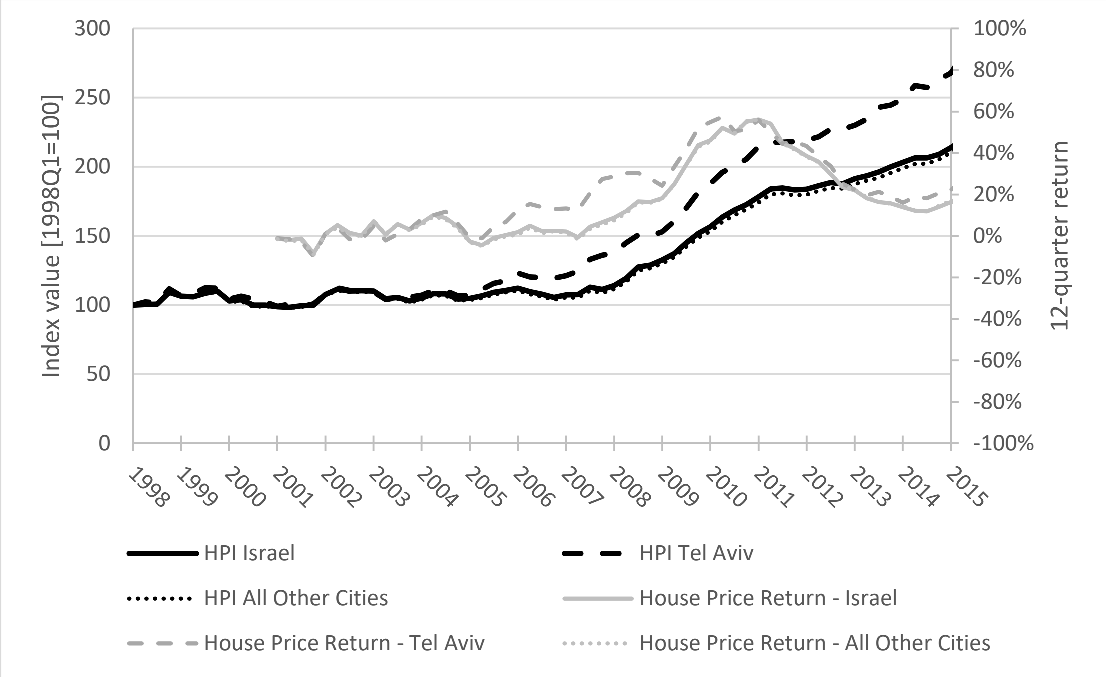
Notes: Standard errors in parentheses. Three asterisks represent significance at the 1% level.

Table 8: Effects of Policy Interventions on Affordability Distance

Variable	All Sample	Sample up to 20km from Tel Aviv	Sample over 20km from Tel Aviv
Column	(1)	(2)	(3)
Constant	6.627*** [0.093]	3.160*** [0.140]	6.896*** [0.115]
$Infrastructure_{t-3}$	-0.352*** [0.045]	-0.193*** [0.070]	-0.487*** [0.060]
$Starts\_TA_{t-2}$	-0.068*** [0.010]	-0.105*** [0.015]	-0.039*** [0.013]
$Starts\_20km_{t-3}$	0.001 [0.004]	0.004 [0.006]	0.001 [0.005]
$IntRate_{t-2}$	-0.140*** [0.006]	-0.124*** [0.009]	-0.153*** [0.007]
Household Controls	Included	Included	Included
LFE	Included	Included	Included
N	53153	23591	29562
R2	0.399	0.41	0.327
Prob(F>0)	0	0	0

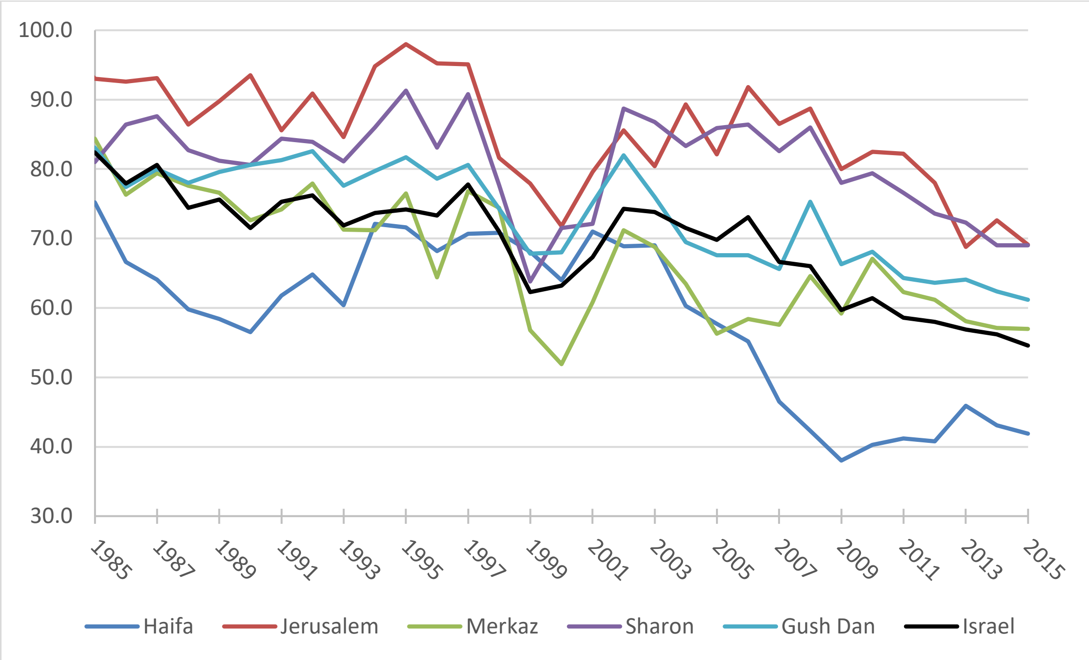
Notes: Standard errors in parentheses. Three asterisks represent significance at the 1% level.

Figure 1: House Price Indexes and House Price Returns: Israel, Tel Aviv and All Other Cities, 1998-2015



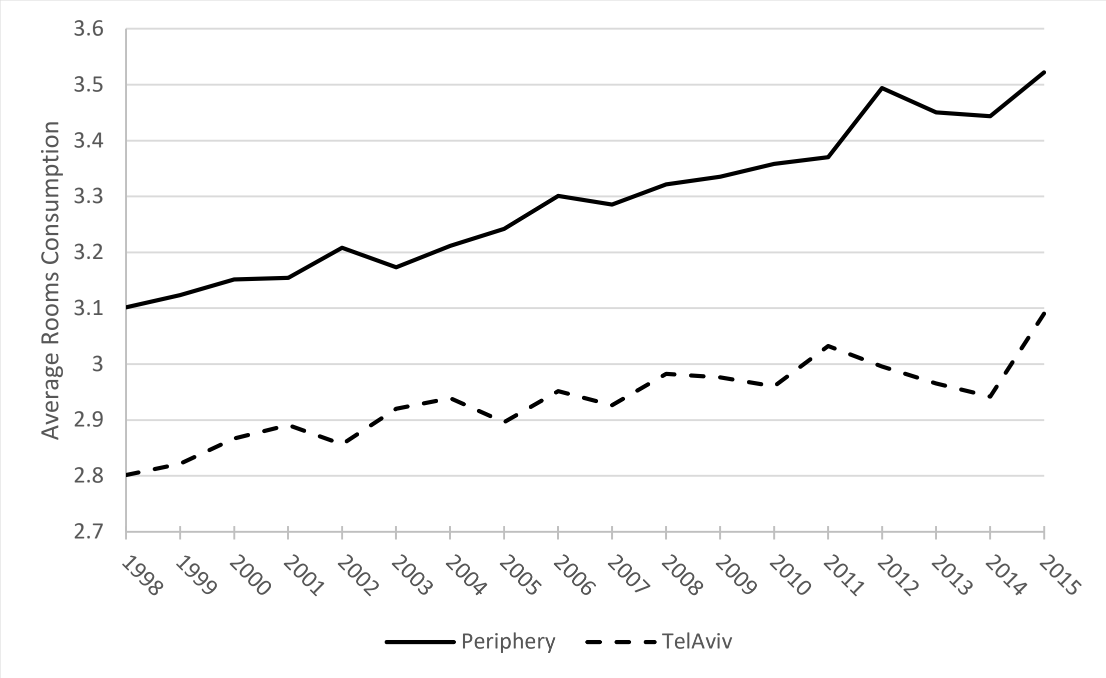
Notes: Black lines represent quality-adjusted House Price Indexes (HPIs), grey lines represent 12-quarters returns. Solid, scatter and dotted lines respectively represent values for the entire sample, values for Tel Aviv, and values for all other cities. We derive the HPIs from the 1998-2015 transaction dataset (see the sample section). The 36-month-returns are calculated based on the corresponding HPI values.

Figure 2: House Prices in Different Geographic Areas in Israel Relative to House Prices in Tel Aviv, 1984-2015



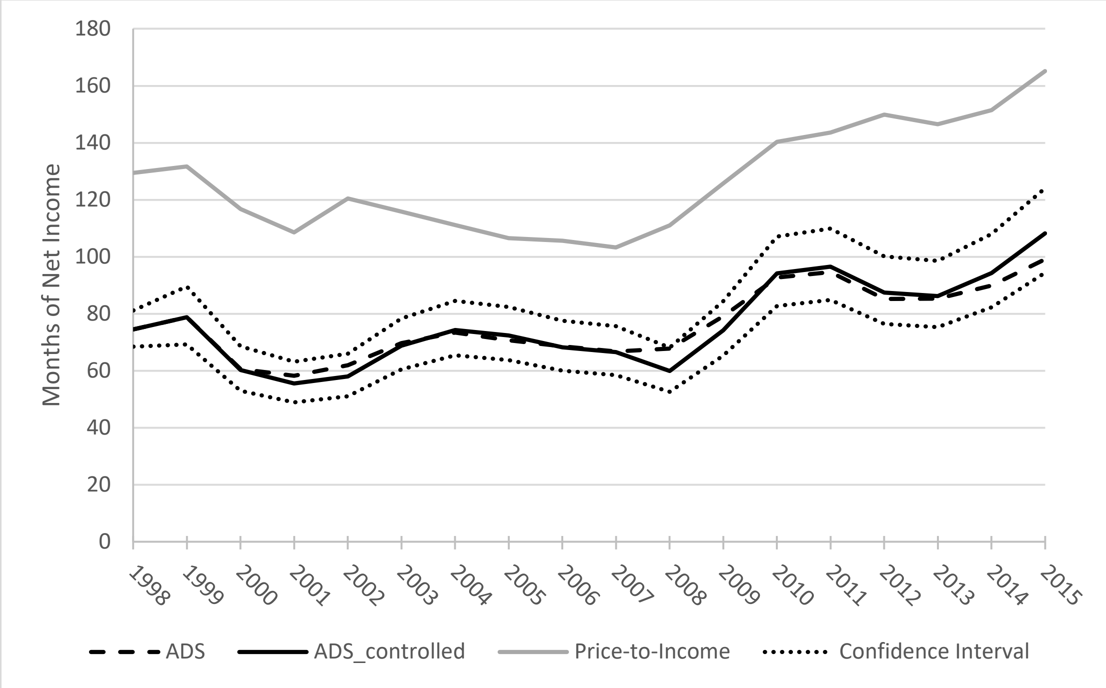
Notes: Prices in Haifa, Jerusalem, Merkaz (center), Sharon, Gush-Dan and Israel average with respect to Tel Aviv Prices. Prices in Tel Aviv at each year are set as 100. Data source: The 2016 Statistical Abstract of Tel Aviv, Center for Economic and Social Research, Tel Aviv Municipality, Table 3.29.

Figure 3: Annual Average Number of Rooms, *NR*, Consumed by Households in and outside of Tel Aviv, 1998-2015



<u>Notes</u>: The figure above attempt to capture changes in housing consumption across the 1998-2015 period. The solid line depicts the average annual number of rooms for households participated in the survey and live outside of Tel Aviv. The scatter line represents the standardized housing consumption in Tel Aviv for the same sample in each year. As described in section 4 above, the standardized Tel Aviv housing consumption for a given year is based on the average housing consumption (measured in number of rooms) that year of households of same composition (same number of adults and children) who live in Tel Aviv.

Figure 4: Affordability Distance to Tel Aviv (*ADS*) and Housing Affordability (Price-to-Income Ratio) 1998-2015

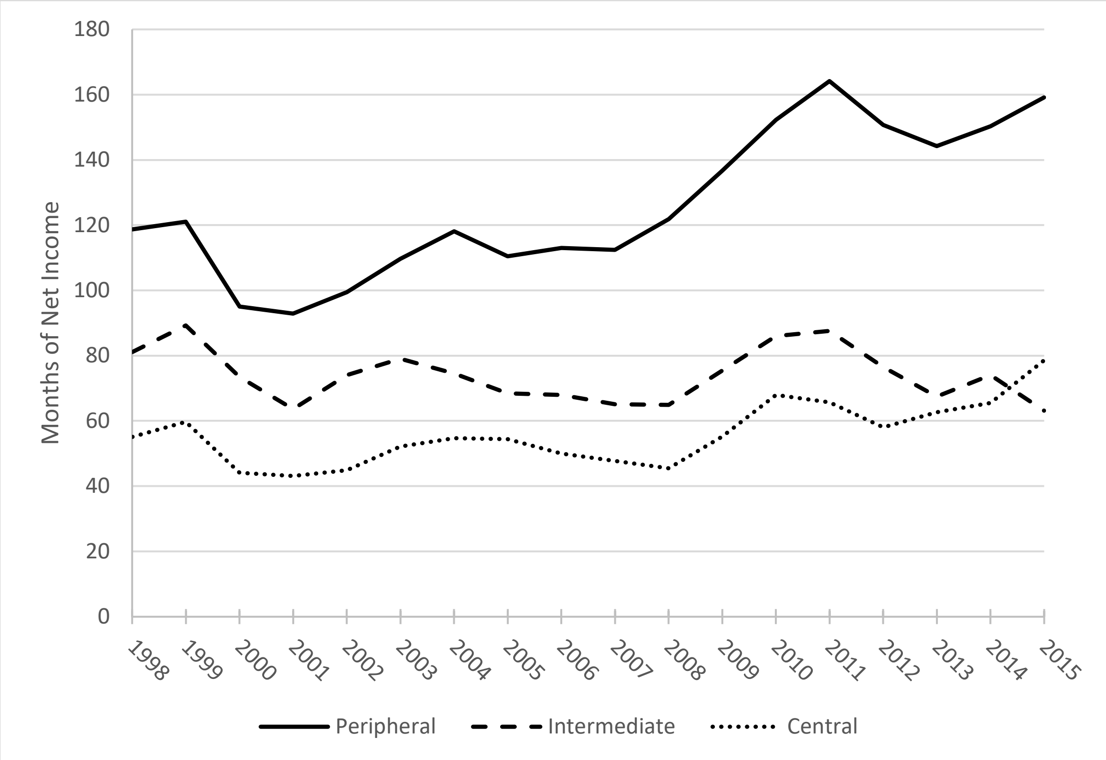


Notes: The figure above plots the annual average values of the ADS for the 1998-2015 period. The scattered line depicts a simple average of ADS across all households; the solid line is a controlled, household-characteristics-adjusted, ADS (dotted lines represent a 90% confidence interval around the controlled ADS); and the grey line is the traditional measure of housing affordability—the price-to-income ratio. To produce the controlled ADS we estimate an equation in the form of: $\ln\left(ADS_{i\in ACY}^{l}\right) = \theta_0 + \theta_1 HHCharacteristics_i + \theta_2 LFE + \theta_3 TFE + \varepsilon$ where *HHCharacteristics$_i$* is a vector of householder characteristics including his/her age, gender, nationality, ethnic origin and education; *LFE* are localities (cities) fixed-effect and *TFE* are time fixed-effects. The estimated vector of coefficients θ_3 is used to plot the controlled ADS values, where in 1998, the controlled ADS is set to the average ADS value so its values can be interpreted as in months of net income as well. Finally, the Y-axis is presented in months of net (after tax) income.

Figure 5: Affordability Distance to Tel Aviv (ADS) by Selected Adult-Children (*AC*) Clusters, 1998-2015

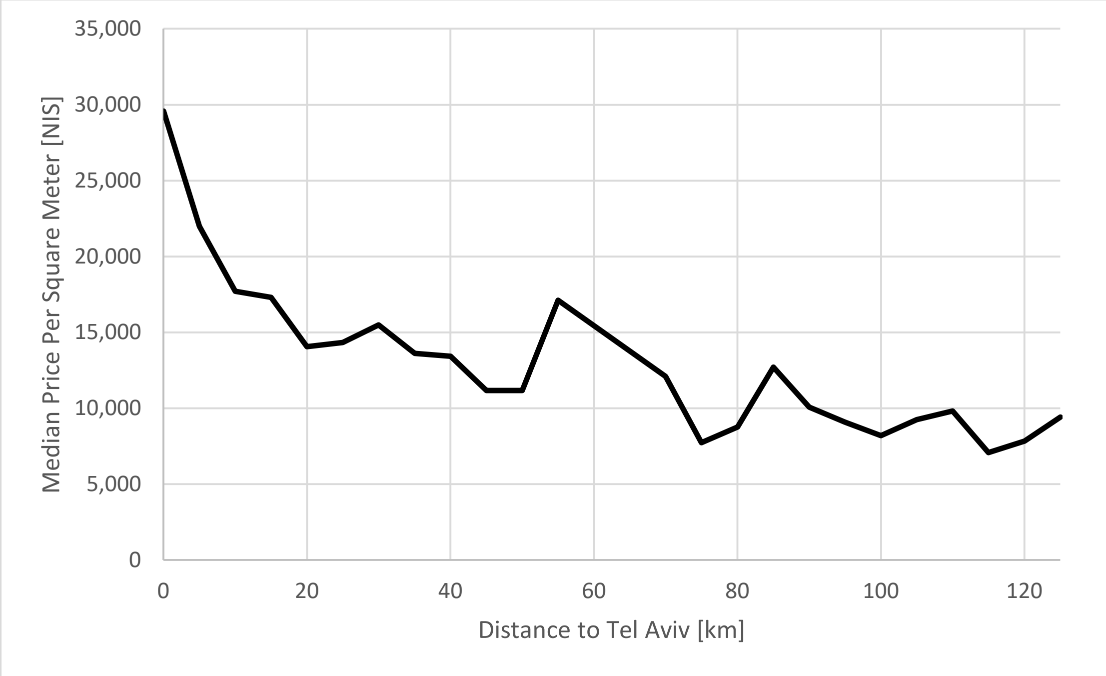
Notes: In the figure above, AC=20 (AC=21; AC=22) stands for a 2-adult-0-children (2-adult-1-child; 2-adult-2-children) household.

Figure 6: Affordability Distance to Tel Aviv (ADS) by Peripheral Clusters, 1998-2015



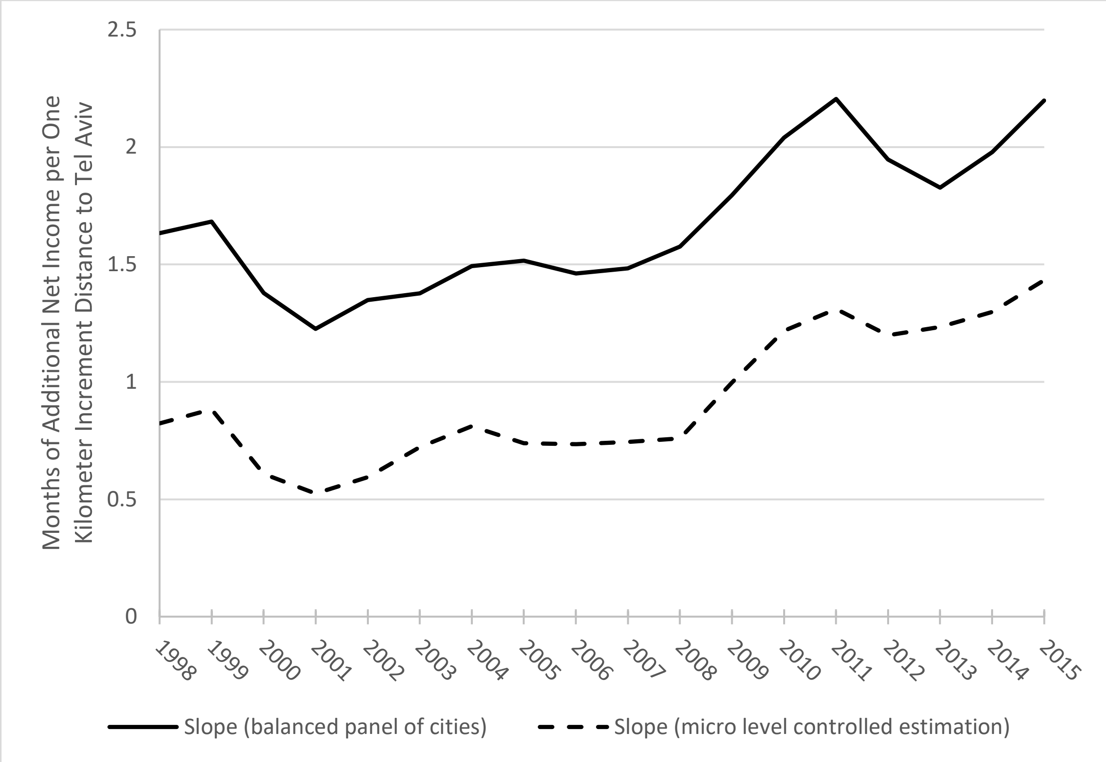
Notes: In the figure above, the solid lines plot average *ADS* values by peripheral clusters, where solid, scattered, and dotted lines represent respectively center, intermediate, and periphery.

Figure 7: Median Housing Price per Square-Meter and the Geographic Distance to Tel Aviv, 2015



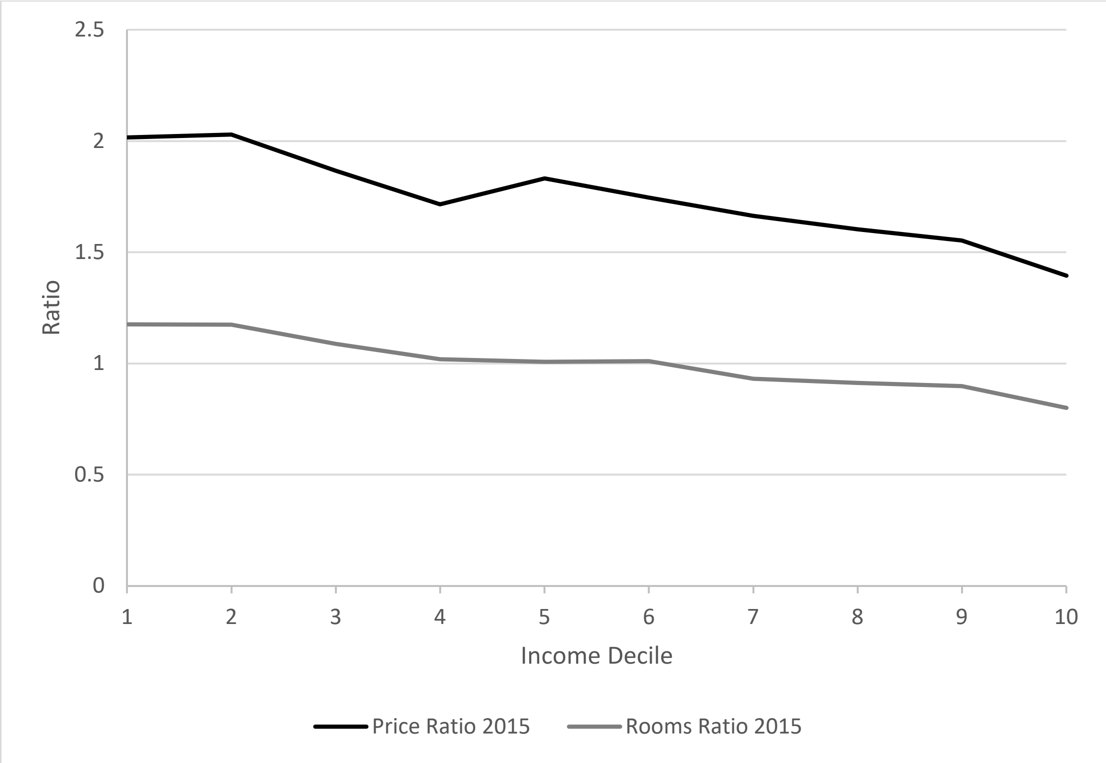
Notes: The figure above plots (transaction-based) median per-squared-meter prices for housing units located up to 125km from the center of Tel Aviv, as of 2015. The point where distance to Tel Aviv equals zero represents the city of Tel Aviv, whereas transactions of units outside of Tel Aviv are grouped in 5km intervals. Transaction price of a unit outside of Tel Aviv, located 0-5km [(*k*-5) – *k*] from the center of the city are plotted in the graph where distance to Tel Aviv equals 5 (*k*).

Figure 8: The association between *ADS* and the physical distance to Tel Aviv, 1998-2015



Notes: The figure above plots 2 proxies for the association between *ADS* and physical distance (measured in kilometers), for the 1998-2015 period. The first proxy, represented by a solid line, derived from a city/year balanced panel of all cities which continuously represented in the household-level surveys used in this paper. This panel includes the distance (in kilometers) between each city and Tel Aviv, *distance*, and the average ADS_i values of the households in the survey that live in city *l* at year *t*, ADS_{lt}. For each year we run a separated cross-sectional (i.e., across cities) regression in the form: $ADS_{l,t} = \theta_t distance_l + \varepsilon_{l,t}$. The solid line plots θ_t for $t = (1998,1999, \ldots ,2015)$. This proxy may be biased due to changes in the characteristics of surveyed households. We therefore calculate a second proxy using micro (household) level data. We assign each household with its city`s distance to Tel Aviv, and interact that value with a dummy variable for each of the survey years, generating *distance*1998-*distance*2015 variables. We then run a pooled regression of all households, in the form of: $ADS_i = \theta_0 + \theta_1 Controls_i + \sum_\tau \theta_{3,t}\, distance \times t_i + \varepsilon_i$. The scatter line plots the estimated values of the $\theta_{3,t}$ parameters.

Figure 9: The Ratios $NR^{S}_{ACY}/NR^{l}_{i\in ACY}$ and $\hat{P}^{S}_{ACY}/\hat{P}^{l}_{i\in ACY}$ by income deciles, 2015



Notes: In the figure above, the black line depicts the ratio of the standardized Tel Aviv unit price to the actual unit price by income deciles and the grey line describes the standardized Tel Aviv housing consumption to actual housing consumption (both measured as number of rooms) by income deciles. All values are for calculated for the 2015 sample. The negative trend in the two lines suggests, as could be expected, that higher-income households experience a lower level of affordability distance distress, consume more housing, and live in pricier units.

Figure 10: Affordability Distance by Income Decile, 2015

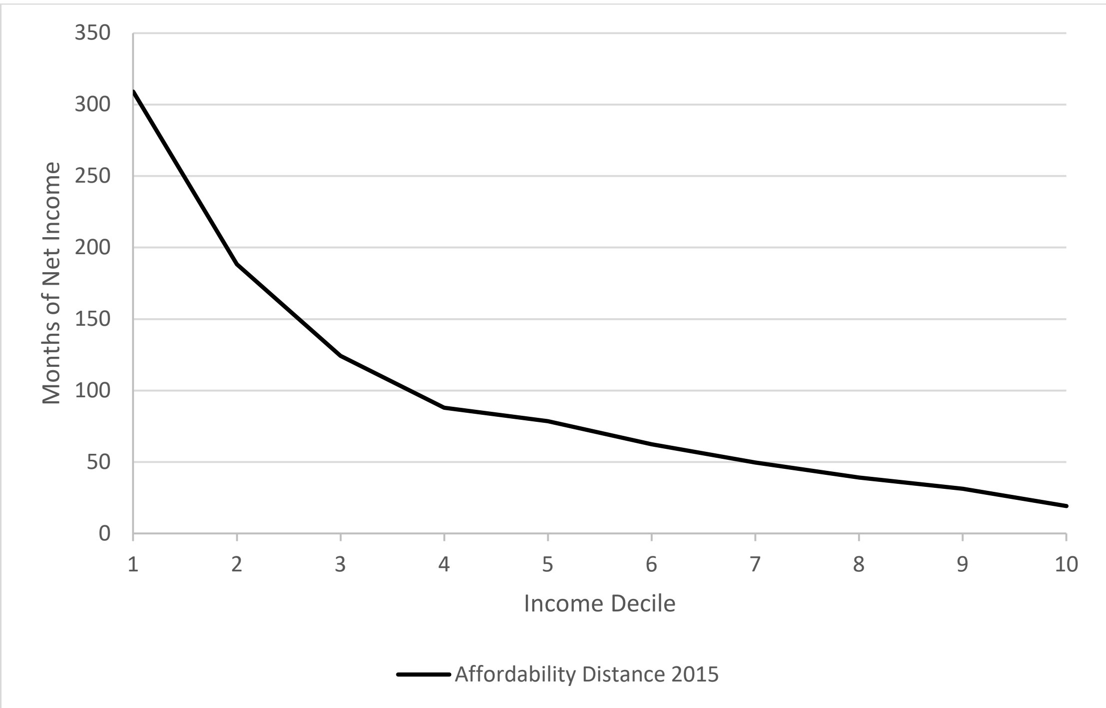
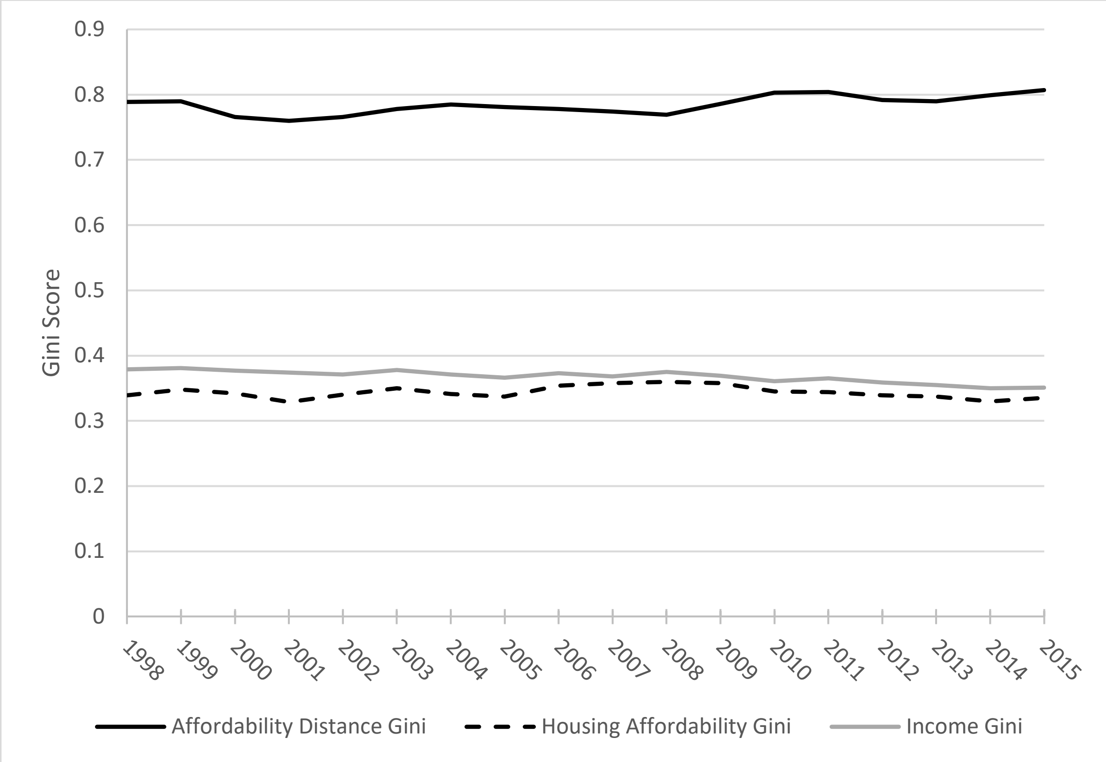


Figure 11: Gini values for: *ADS*, Housing Affordability, and Income, 1998-2015



Notes: The figure above plots Gini scores for ADS (black, solid), housing affordability (black, scattered) and income (grey) for the 1998-2015 period. Since *ADS* and the price-to-income ratios are negative properties (i.e., household with lower values of them are better-off), and following Ben-Shahar and Warszawski (2016), we inverse their values for the calculation of the Gini score. In addition, since ADS can be negative for some households, we limit its value to 1 (i.e., if the ADS of a household is 1 or less, it is calculated as 1). Gini scores range from 0 to 1, where a Gini score of 0 stands for complete equality (e.g., the relevant resources are evenly distributed across the population) and a value of 1 stands for a situation in which one individual in (or a small share of) the group have all the resources, while all the others have nothing.

Appendix

Derivation of $ADS^{S\to l}_{i\in ACY}$

We compute the$ADS^{S\to l}_{i\in ACY}$ measure as follows: For each city *l* (excluding the superstar city) and each cluster *ACY*, we use those households who live outside the superstar city to compute the *standardized* city *l* housing consumption of that cluster, denoted by ACY^{l}. The standardized housing consumption of each ACY^{l}, is then its average room consumption:

(A1)

$$NR^{l}_{ACY} = \sum_i NR^{l}_{i\in ACY}/N^{l}_{ACY},$$

where the index *i* represents households, $NR^{l}_{i\in ACY}$ is the room consumption of household *i* in cluster ACY in city *l* and N^{l}_{ACY} is the number of households in ACY and city *l*.

Following the estimation of equation (2), we compute

(A2)

$$\hat{P}^{S}_{i\in ACY} = EXP\left[\hat{\gamma}_{1,S} + \hat{\gamma}_{2,S}NR^{S}_{i\in ACY} + \hat{\gamma}_{3,S}NR^{S}_{i\in ACY} \times Floor^{S}_{i\in ACY} + \hat{\vec{\gamma}}_{4,S}CHARACTERISTICS^{S}_{i\in ACY} + \hat{\vec{\gamma}}_{5,S}TFE^{S}_{i\in ACY} + \hat{\sigma}^{2}_{l}/2\right] \text{ for all } i \in ACY \text{ in } S$$

and

(A3)

$$\hat{P}^{l}_{ACY} = EXP\left[\hat{\gamma}_{1,l} + \hat{\gamma}_{2,l}NR^{l}_{ACY} + \hat{\gamma}_{3,l}NR^{l}_{ACY} \times Floor^{l}_{ACY} + \hat{\vec{\gamma}}_{4,l}CHARACTERISTICS^{l}_{ACY} + \hat{\vec{\gamma}}_{5,l}TFE + \hat{\sigma}^{2}_{l}/2\right] \text{ for all } ACY \text{ and } l,$$

where *i*, *l*, and *S* represent households, cities other than the superstar, and the superstar city, respectively; $NR^{S}_{i\in ACY}$, $Floor^{S}_{i\in ACY}$, and $CHARACTERISTICS^{S}_{i\in ACY}$ on the right-hand side of (A2) are the actual number of room consumption, floor location, and other asset characteristics, respectively, of the housing unit occupied by household *i*, $i \in ACY$, in the superstar city;[27] NR^{l}_{ACY}, $Floor^{l}_{ACY}$, and $CHARACTERISTICS^{l}_{ACY}$ on the right-hand side of (A3) are the standardized number of room consumption of the group ACY^{l} (from equation [A1]), and floor location as well as a vector of other asset characteristics at their average value across the group ACY^{l}, respectively; $\hat{\sigma}^{2}_{l}$ is estimated variance of $\varepsilon_{1,j\in l}$ from (2)—the required adjustment in the price projection in (A2) and (A3) that follows from the logarithmic functional form in (2); and

[27] Recall that, while we observe $NR^{S}_{i\in ACY}$, we do not directly observe $CHARACTERISTICS^{S}_{i\in ACY}$ in equation (A2). Hence, in our empirical implementation we proxy $CHARACTERISTICS^{S}_{i\in ACY}$ by a vector of asset characteristic at their average value in *S*.

$\hat{\gamma}_1 - \hat{\gamma}_3$ and $\hat{\vec{\gamma}}_4 - \hat{\vec{\gamma}}_5$ are estimated coefficients and vector of coefficients, respectively, that follow from equation (2). That is, based on the estimated coefficients from equation (2) we compute $\hat{P}^S_{i \in ACY}$ in (A2), the projected price associated with the household *i*'s *actual* housing consumption in the superstar city, and $\hat{P}^l_{ACY}$ in equation (A3), the projected price for household *i*'s associated consumption-adjusted housing bundle (by household cluster, ACY) in city *l*.

Finally, given the net income of household *i* in *S*, $Income^S_{i \in ACY}$, we compute:

(A4)

$$ADS^{S \to l}_{i \in ACY} = (\hat{P}^S_{i \in ACY} - \hat{P}^l_{ACY})/Income^S_{i \in ACY} .$$