Regional Science and Urban Economics 49 (2014) 68–83

Contents lists available at ScienceDirect

Regional Science and Urban Economics

journal homepage: www.elsevier.com/locate/regec

# Anchoring and housing choice: Results of a natural policy experiment

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ARTICLE INFO

*Article history:*
Received 27 January 2014
Received in revised form 20 June 2014
Accepted 9 July 2014
Available online 1 August 2014

*JEL classification:*
D03
C9
R38

*Keywords:*
Behavioral economics
Anchoring
Housing choice
Public policy

ABSTRACT

This research employs data from a natural experiment to assess the effects of behavioral heuristics on housing choice and public program management. The analysis focuses on programs designed to privatize public housing in Israel. The government programs provided the tenants with a call (real) option to purchase their rental unit at a discounted exercise price. We employ a large panel of transactions over the 1999–2008 period to evaluate whether the tenants used prior program price reductions as anchors in their purchase decisions. The results of hazard model estimation provide strong evidence of anchoring in the timing of home purchase. Further, model simulation suggests that by accounting for the anchoring heuristic, program managers could have both accelerated purchases and significantly increased government revenues associated with privatization. We also find evidence that anchoring varies with individual and market characteristics.

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## 1. Introduction

Anomalies in household economic behavior have long been the subject of theoretical inquiry and experimental analysis. Seminal work by Tversky and Kahneman (1974), for example, suggests that people tend to excessively focus on a specific piece of information and use it as an *anchor* for future decisions. The authors state that "in many situations, people make estimates by starting from an initial value that is adjusted to yield the final answer […] adjustments are typically insufficient. That is, different starting points yield different estimates, which are biased toward the initial values. We call this phenomenon anchoring" (page 1128). Experimental findings by Kahneman and Knetsch (1993), Ariely et al. (2003) and many others provide support for the anchoring hypothesis. Despite the preponderance of laboratory findings, few studies have applied empirical data to demonstrate the importance of heuristics to household decisions or to public program management.[1]

Over the past decade, the Israeli government sought to privatize public housing via an offer to sell rental units to tenants at a discount from the market price. The reductions were based on tenant demographic and locational characteristics and changed over time.

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[1] Several definitions of the anchoring heuristic are provided in the literature [see, for example, Chapman and Johnson (2002)]. Our research is further relevant to a growing literature that studies whether an uninformative *number* (the anchor) influences the judgment of the decision-makers [see, among many others, Tversky and Kahneman (1974), Chapman and Johnson (1994), Strack and Mussweiler (1997), and Wansink et al. (1998)]. Also, it should be noted that the experimental methodology often employed by psychologists to examine heuristics suffers from many shortfalls, including concerns as to whether (1) behavioral patterns observed under artificial laboratory conditions are replicated in real-life decision-making (see, for example, List, 2003; Levitt and List, 2007, 2008; DellaVigna, 2009); (2) conclusions drawn from laboratory experiments regarding individuals' consistency of preferences are reliable (see, for example, Knetsch, 1989, 1992); and (3) laboratory conditions are appropriate, given that subjects often are offered limited possibilities and relatively low incentives to cooperate and, generally, are not "punished" for incorrect decisions.

http://dx.doi.org/10.1016/j.regsciurbeco.2014.07.004
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The tenants had the opportunity to either accept or decline successive government sales offers. Our research employs survival analysis to empirically assess whether public housing tenants used prior price reductions as anchors (or reference prices) in the timing of home purchase.[2]

The analysis proceeds as follows. First, we assess the stationarity of the government price reduction time-series. Results of unit root analyses provide evidence that all series are non-stationary. Hence we could not reject the null hypothesis that the government price reduction time-series follow a random walk. Those findings together with other analyses (below) indicate that tenants could not have forecasted the successive price reduction regimes so as to strategically exercise the purchase option.

We then statistically assess the role of anchoring heuristics in timing of home purchase. We use survival analysis to estimate whether the average of the past price reduction rates anchored the tenant's reaction to the current reduction rate. In that analysis, we also stratify the sample and assess the heterogeneity of results across periods when the current reduction rate is above or below the reference (anchor) reduction rate. We subsequently employ the results of the survival analysis to simulate purchase outcomes under alternative price reduction schemes. This allows us to evaluate whether program managers could have enhanced program execution via an explicit accounting for the buyer "reference reduction effect" in determination of the price reduction algorithm. Finally, we examine the sensitivity of the estimated anchoring effects to such features as age of household head, household income, and percentage of public housing units in the structure.[3]

The results provide strong evidence of anchoring in home purchase decisions. Estimated tenant responses to the anchor are significantly different from zero. Further, the hazard rate associated with purchase option exercise (i.e., the probability of purchasing the unit), *decreases* 8% for every 1% increase in the anchor in excess of the current reduction rate. In contrast, when the anchor is less than the current reduction rate, a 1% increase in the anchor leads to a significant 1% *increase* in the hazard rate. As shown in the model simulation, by accounting for the anchoring effect, policymakers could have both significantly accelerated the sale of public housing units and substantially reduced privatization costs. Finally, as anticipated, the results indicate that the estimated anchoring effect varies with characteristics of home purchasers.

The contribution of the research is twofold. First, our evidence on the role of the anchoring heuristic derives not from the laboratory but rather from a unique, real-world natural policy experiment. In that regard, our sampled households face decisions that involve substantial financial resources and have important long-term household economic consequences. Second, our analysis demonstrates a simple, practical, and direct application of cognitive biases to public policy. It shows how policymakers could use the estimated anchoring effect to more efficiently attain programmatic objectives. To the best of our knowledge, this paper is the first to examine the role of heuristics in a public program context.[4]

[2] Following Tversky and Kahneman (1974), we use the terms "anchoring" and "anchor" throughout the paper [see also Ariely et al. (2003)]. An alternative and equivalent terminology is "reference price" in the cases where the anchor refers to the monetary price of a product [e.g., Simonson and Tversky (1992), Ariely and Simonson (2003), Bajari and Hortacsu (2003), Kamins et al. (2004), Stern and Stafford (2006),Hoppe and Sadrieh (2007), and Rosenkranz and Schmitz (2007)].

[3] Here the analysis is motivated, in part, by studies by Genesove and Mayer (2001) and List (2003, 2004), who examine the effect of experience on heuristics. List (2003, 2004) demonstrates, as anticipated from rational expectations theory, that unlike inexperienced actors, experienced card collectors exhibit no status-quo bias.

[4] Also, unlike most tenure choice studies, public housing tenants may either purchase or continue to rent the identical housing unit – hence, the tenure choice pertains to the same property. In contrast, studies dealing with movers from one location to another [e.g., Simonsohn and Loewenstein (2006)], largely do not control for variations in the structural features of the dwellings in question.

The plan of the paper is as follows. The following section provides background and literature review. Section 3 provides a brief description of the sale programs, while Section 4 describes the data, including variable definitions and related summary statistics. Section 5 presents the empirical model whereas Section 6 provides related estimation results in support of anchoring effects. Section 7 describes simulation of alternative reduction rate schemes and demonstrates practical implications of the anchoring heuristic in the assessment of management of public program design. Section 8 assesses the robustness of results to model specification while Section 9 evaluates the sensitivity of anchoring findings to individual interactive terms. Finally, Section 10 provides summary and concluding remarks.

## 2. Background

The majority of evidence in support of the anchoring heuristic derives from experimental settings. That literature covers a range of applications, notably including papers by Plous (1989), Wright and Anderson (1989), and Yamagishi (1994) in the estimation of risk and uncertainty; Johnson and Schkade (1989), Carlson (1990), and Chapman and Johnson (1994) in the evaluation of monetary lotteries; Cervone and Peake (1986) in assessment of self-efficacy; Davis et al. (1986) in judgments of spousal preferences; Chapman and Bornstein (1996) and Englich and Mussweiler (2001) in jurors' decision-making; Dodonova and Khoroshilov (2004) in online auctions; Joyce and Biddle (1981) and Butler (1986) in financial auditing; and Ariely et al. (2003) in coping behavior associated with disturbing noises.[5] All of these laboratory-based experiments compare behaviors among groups of subjects exposed to different single anchors. With the exception of Ariely et al. (2003), none of these studies focus on a series of successive anchors.

In contrast to experimental literature, empirical analyses (including field experiments) of behavioral anomalies are less prevalent. Accordingly, the literature contains only a few empirical studies focusing exclusively on anchoring. Relevant examples include studies of endowment effects among card collectors [List (2003, 2004)]; sales programs for sanitation and health products in Zambia and Kenya [Ashraf et al. (2010) and Dupas (2010)]; and the impact of the seller's reservation price on the final price in online internet bid auctions [see Ariely and Simonson (2003), Bajari and Hortacsu (2003), Kamins et al. (2004), Stern and Stafford (2006), Hoppe and Sadrieh (2007) and Trautmann and Traxler (2010)].

In the housing literature, a few empirical studies have examined behavioral anomalies. As would be expected, anchoring appears to be important to real estate appraisal and to seller asking price (e.g., Northcraft and Neale (1987)). Genesove and Mayer (2001) and Anenberg (2011) show that loss aversion affects condominium asking prices, in that the purchase price serves to subsequently anchor the unit price at re-sale. Simonsohn and Loewenstein (2006) demonstrate the importance of anchoring to rental housing consumption among movers. They suggest that rental rates in the prior location serve as anchors for movers to new locations.

In the wake of the recent severe boom–bust cycle in housing, the efficacy of government interventions and related housing assistance programs is of broad concern. While DiPasquale et al. (2003) and Olsen (2003) review and assess housing assistance programs in the U.S., we are unaware of any study other than our own that indicates the importance of heuristics to policy implementation and housing program design. Further, in many countries, notably including the U.K., China, Russia, and numerous Eastern European nations, major programs have been launched to privatize the substantial stock of public housing. Below we apply the real option approach to assess the role of the

[5] For a thorough review of the literature on anchoring and other behavioral anomalies see, for example, Chapman and Johnson (2002) and DellaVigna (2009).

anchoring heuristic in the design and management of Israeli programs to privatize public housing.

## 3. The sale programs

Over the 1999–2008 period, the Israeli government sought to privatize public housing via an offer to sell rental units to tenants at a discount from the market price. Overall, six consecutive sales programs were conducted.[6] Tenants had the opportunity to either accept or decline the successive government sales offers. While the criteria for computing the price reductions (from the fair market value of the dwelling) were based on tenant demographic and locational characteristics, those algorithms varied substantially over time and place.[7]

The table in Appendix A shows the origination and termination dates of each sale program and the detailed criteria by sale program for tenant offer price reductions.[8] As is evident in the table, the duration of the sales programs varied substantially. Further, the algorithm for determining tenant price reductions changed considerably from one program to the next. While current price reduction criteria were available to the public, the timing of successive programs and the evolution in future criteria were erratic and unpredictable (see further discussion below).

For example, as seen in the table, the second sales program was in effect for 41 months, whereas the fourth program lasted just 7 months. In the first sale program, price reductions were based on a variety of individual characteristics, whereas in the second program, duration of residence in public housing was the primary factor for determining the level of price reduction. By the sixth program, price reductions were based on residence in a priority region together with family status (single persons versus couples), number of children, and disability status. Importantly, as seen in the table, both the factors weighted in the price reduction algorithm as well as the weights assigned to those factors varied from one program to the next.[9]

As shown in Appendix B, the price reduction rates varied considerably across stratifications of the sample by various socio-demographic, locational, and dwelling characteristics (including location, duration in the public housing project, number of children under 21 years old, income, and type of structure). Further, for a given stratification, the reduction rates do not appear to follow any particular pattern.

Appendix C reports on results of four different statistical tests for unit roots in the offer price reduction time-series. Results of the analyses provide evidence that the series in all panels are non-stationary. Hence we could not reject the null hypothesis that the offer price reduction time-series follow a random walk. Those findings together with other tests reported in Section 8 indicate that tenants could not have forecasted the successive price reduction schemes so as to strategically exercise the purchase option.

## 4. A description of the sample

Data for the analysis were obtained from Amidar Ltd., the largest public housing corporation in Israel. The raw sample includes the universe of 58,665 dwelling units managed by Amidar – approximately half of the total public housing stock in Israel [see Bar-Dadon (2000) for further details]. Of those units, 16,213 were purchased during 1999–2008. Unlike much of the empirical literature, the panel nature of our data allows us to examine resident response to successive program incentives, controlling for household socio-economic and demographic as well as market characteristics.

Our analysis focuses on the role of the anchoring heuristic in timing of home purchase. Accordingly, the sample is restricted to the subset of tenants who exercised the purchase option.[10] From the raw sample we thus generate an unbalanced panel of 6853 public housing tenants who purchased their unit.[11] We assess the response of tenants to varying price reduction rates over a period of up to 114 months. The panel structure enables us to employ survival analysis to predict the proportion of households that exercise the purchase option in each period as well as the time duration until tenant option exercise. In this context, tenants fail to survive (failure = 1) and are excluded from the sample at the time of their switch from renter to owner status.[12]

Table 1A provides summary statistics on the cross-section of buyers at the date of home purchase option exercise. As indicated in the table, the average appraised value (before price reduction) of the purchased housing units (*APPT_VALUE*) at the purchase date was $89,509 with a standard deviation of $29,387.[13] In comparison, units of similar size transacted at about twice that price in the private sector.[14] Table 1A further indicates an average rate of price reduction of those units from appraised value ($RED_{i,t}$) was 78% or $69,955 in dollar value ($RED\_DOLLAR_{i,t}$) at the date of purchase. As is evident, public housing tenants exercised the purchase option at deeply discounted values.

Table 1A further provides information on $ANCHOR_{i,t}$, the mean of all prior ($t$-1) reduction rates for tenant $i$ at the date of purchase.[15] As shown, the average of $ANCHOR_{i,t}$ was 53% with a standard deviation of 22%. These figures imply that the purchase option typically was exercised following an additional 25% discount over the prior mean reduction rate.

[6] Note that as of September 2008, the sixth sale program was no longer valid. Subsequently, the privatization programs were discontinued.

[7] It should be noted that reductions were set relative to the unit's appraised fair market price as determined by the Chief Government Appraiser. The appraisal of each unit was conducted upon a request initiated by its resident. The unit's reduction rate was determined independent of it's appraised value and based on the socio-demographic guidelines in place at the time by the Israeli Ministry of Housing and Construction. Furthermore, within 5 years following purchase option exercise, the buyer can resell the unit only if she purchases a more expensive unit in the open market. Otherwise, a resell entails a loss of a substantial part of the attained reduction. Under these conditions, resell is effectively restricted during the initial 5 year period after purchase.

[8] Information on reduction rates was provided by Amidar Ltd.

[9] Also, note that two types of caps were imposed on the computed reductions: one for the marginal contribution of each factor to the total price reduction and another on the sum of marginal reductions per household.

[10] Indeed, the decision not to purchase the dwelling may owe to household affordability constraints or other considerations unrelated to anchoring behavior among tenants.

[11] Observations omitted from the sample include cases of missing information regarding rent payments and reduction rate at the date of purchase and tenants who entered the sample after $t = 0$. Also, it should be noted that results obtained from estimating only the sample of purchasers were found to be robust to those obtained while using the full sample containing both purchasers and non-purchasers. We are grateful to the assistance of Ronit Gerafi from Amidar LTD for providing us with detailed information regarding the raw data and to Smadar Shatz for her invaluable assistance in processing the data on the reduction rates for each tenant across periods.

[12] Two reasons justify our approach as opposed to the alternative, namely an unbalanced panel of six sale programs. Those reasons include: (1) the latter does not weigh the very dissimilar length of the different sale programs in months; and (2) reduction rates may vary during the period of each sales program due to variations in the demographic characteristics, such as the birth of a new child. In such cases, the latter data structure imposes information loss. Also, a major advantage of our dataset is the fact that the reduction rates offered to tenants are determined exogenously by the government. The reduction rates are calculated based on personal demographic and locational characteristics of the unit. Consequently, there is no endogeneity problem between the survival time until the exercise of the purchase option and the reduction rates offered to tenants over time.

[13] Referring to the unbalanced panel, *APPT_VALUE* has been computed across all time-periods based on the value of the housing unit at the date of purchase deflated backward for each survival time. Deflation is based on housing price indices of average transaction prices for 9 statistical regions published by the Israel Central Bureau of Statistics. For the convenience of the reader, all the variables measured in *NIS* (Israeli local currency) are converted to dollars, where 1 *NIS* roughly equals $0.25.

[14] Compared to the average value of a 3.18 room public housing units, the non-quality adjusted mean value of a transacted housing unit in the private market was 171,450 dollars with a standard deviation of 12,150 dollars.

[15] We further examined other potential anchors including the mean over past reduction rates ending at the end of the previous reduction rate regime as well as the initial, mean, last, and maximum price reduction rate of tenant $i$ at time $t$. While all of these anchors were found to be statistically significant (particularly the past maximum reduction rate), for purposes of brevity we report on the outcome of the anchor defined as the mean of all prior ($t$-1) reduction rates. That anchor was highly statistically significant and had several other salutary features, notably including: (1) it preserves the memory of all prior reduction rates given the up to 114 months until option exercise occurs; and (2) it accounts as well for reduction rate volatility by weighting duration of time until variations in reduction rates occur. Results from estimating the other potential anchors are available upon request.

**Table 1A**
List of variables, definitions, and summary statistics: cross-section of buyers at the date of purchase.

| Name | Variable definition | Avg. | Std. | Min | Max |
|---|---|---|---|---|---|
| $APPT\_VALUE_i$ ($) | Value of housing units translated to dollars | 89,509 | 29,387 | 20,625 | 269,193 |
| $RED_i$ | Current price reduction rate in percentage points | 78 | 16 | 5 | 95 |
| $RED\_DOLLAR_i$ | Current price reduction rate translated to dollars | 69,955 | 27,380 | 1963 | 176,163 |
| $ANCHOR_i$ | Accumulated average of all previous (up to *t*-1) price reduction rates | 53 | 22 | 1 | 91 |
| $BENEFIT_i = RED\_DOLLAR_i - \frac{MR_{i,t}-SR_{i,t}}{r_t}\left[1-\frac{1}{(1+r_t)^{N_i}}\right]$ | The difference between subsidies embedded in purchase and rent | 60,569 | 30,103 | −62,340 | 161,401 |

Note: Table 1A provides summary statistics for the primary variables of interest for tenants occupying 6,853 purchased dwelling units ($i=1,2,...,6,853$) at the date of purchase. All the variables measured in NIS (the local Israeli currency) are converted to dollars, where 1 NIS roughly equals $0.25. The $\frac{MR_{i,t}-SR_{i,t}}{r_t}\left[1-\frac{1}{(1+r_t)^{N_{i,t}}}\right]$ variable measures the present value of rent subsidies given to public-housing tenants at the date of purchase, where *MR-SR* is the difference between monthly market and subsidized rent, $r_t$ is the monthly yield on 1-year government bond (Bank of Israel) and *N* is life expectancy in months based on the age of household head and life expectancy table published by the Israel Central Bureau of Statistics.

Table 1A also presents information on $BENEFIT_{i,t}$, a control variable that computes the return from exercising the purchase option at a price reduction net of the forgone present value of the expected rent subsidy from continuing to rent. $BENEFIT_{i,t}$ is equal to $RED\_DOLLAR_{i,t} - \frac{MR_{i,t}-SR_{i,t}}{r_t}\left[1-\frac{1}{(1+r_t)^{N_{i,t}}}\right]$, where *MR* and *SR* are the market and subsidized rent on the property of household *i* at time *t*, $r_t$ is the monthly yield on the 1-year government bond (Bank of Israel), and $N_{i,t}$, is *i*'s life expectancy in months based on the age of household head at time *t* and life expectancy data provided by the Israel Central Bureau of Statistics. The average value of *BENEFIT* at the date of purchase equals 60,569 dollars.[16]

Table 1B presents summary statistics for the sample panel across all time periods (excluding the date of purchase). Note that the sample panel exhibits both a lower average price reduction rate ($RED_{i,t}$) of 45% and a lower $ANCHOR_{i,t}$ of 37%. The table further shows stratification of the sample into periods where the difference $RED_{i,t} - ANCHOR_{i,t}$ is negative ($NEG = 1$ and zero otherwise); periods where $RED_{i,t} - ANCHOR_{i,t}$ is positive ($POS = 1$ and zero otherwise); and periods where $RED_{i,t} - ANCHOR_{i,t}$ is zero [$(1 - NEG_{i,t}) \times (1 - POS_{i,t}) = 1$ and zero otherwise]. As shown, $RED_{i,t} - ANCHOR_{i,t}$ is positive in just over half of the sample periods. That difference is negative in 28% of the sample periods and unchanged in 21% of the sample period.

Table 1B includes other controls used in the survival analysis. Among those controls, the net benefit associated with purchase option exercise ($BENEFIT_{i,t}$) across all periods (excluding the date of purchase) is 27,593 dollars. Information on the annual level of current income ($INCOME_i$) is available for only 1,002 of the 6,853 tenants included in the sample. In the next section, we address the censoring of income and the fact that current income is a poor proxy for permanent income.[17] As shown in the table, the average current annual income of sampled reporting households is 11,306 US dollars.[18] Also, on average, the net-of-discount purchase price is equivalent to about 2-1/2 years of earnings.

Other controls include the cost of mortgage credit, house price volatility, and house price appreciation.[19] On average, the annual long-term mortgage rate ($MORTGAGE_t$) was 6.06%. Further, based on indices of average transaction prices for the 9 statistical regions in Israel (Israel Central Bureau of Statistics), house price volatility, as measured by the standard deviation of the annual yield on housing prices ($YIELD\_STD_t$), averaged 4.0%. The average annual appreciation rate ($APPRECIATION_{i,t}$) over the sample period was 2.6%.

The survival analysis further controls for socio-demographic characteristics of households in the sample. Those controls include duration of residence of the household in the public housing unit ($DURATION_{i,t}$), number of children ($CHILDREN_{i,t}$), age of household head ($HEAD\_AGE_{i,t}$), disability status ($DISABILITY_i$), tenant confined to wheelchair ($WHEELCHAIR_i$), and $MARRIED_i$, $DIVORCED_i$, $WIDOW_i$, $SINGLE\_PARENT_i$ and $SINGLE_i$. As shown in Table 1B, the average duration of tenant residence in public housing was about 22 years. About one-third of households had at least 1 child (under 21 years of age) at the date of purchase, while the average number of children was 2 to 3. Almost 5% of the tenants were physically-disabled and 1% was confined to a wheelchair. As regards to marital status, some 48% of the tenants were married, 6% were divorced, 16% were widows, about 15% of tenants were single parents, and 15% were single. Finally, the average age of the household head was 62 years.[20]

Finally, as shown in Table 1B, the analysis controls for dwelling unit and building structural characteristics. They include the percentage of public housing units in the building ($PUBLIC_i$), the age of the structure in years ($CONST\_AGE_{i,t}$), a dummy variable that equals 1 if there is an elevator in the building ($ELEVATOR_i$), the story on which the unit is located ($FLOOR_i$), the number of stories in the structure ($FLOORS_i$), the number of rooms in the dwelling unit ($ROOMS_i$), the area of the dwelling unit in square feet ($AREA_i$), and a dummy variable that equals 1 in the case of a detached housing unit ($DETACHED_i$). As indicated in the table, the typical public housing unit is a 798-square feet, 3-room apartment, located on the second floor. Public housing units typically comprise about three-quarters of building total dwelling units.[21] Those buildings typically are 32 years old, low-rise, 4-story structures lacking an elevator. Eight

[16] The mean value of BENEFIT at the date of purchase includes the mean of RED_DOLLAR ($69,955) net of $\frac{MR_{i,t}-SR_{i,t}}{r_t}\left[1-\frac{1}{(1+r_t)^{N_{i,t}}}\right]$ ($9386). The computation of $\frac{MR_{i,t}-SR_{i,t}}{r_t}\left[1-\frac{1}{(1+r_t)^{N_{i,t}}}\right]$ assumes that tenants are expected to stay in the public housing unit for the rest of their lives. This is based on the considerable shortage of public housing units on one hand and the costly alternative of units in the private market on the other hand. Note that while the average age of the household head is 62 the mean value of the duration in the public housing residence is 23 years. Finally, as public housing in Israel has a long waiting list, households are often offered an all-or-nothing choice of a particular unit when they reach the top of the list and thus the actual benefit is likely to be below the observed subsidy.

[17] Unlike the United States, low-income households in Israel are generally exempted from filing tax returns. Starting in November 2005, public housing tenants were required to file a report documenting their level of income. However, there were only limited sanctions put into place by the Ministry of Housing and Construction for not filing a report. Accordingly, the policy provided an incentive for high-income households to avoid filing such a report.

[18] The average annual net income per household in Israel over the examined period was about $30,000. The $11,306 figure matches the lowest income decile in Israel.

[19] We also included an affordability term defined as the ratio of net ownership price to net rent. This term, however, was statistically insignificant and hence was not included in the final regression output.

[20] A number of factors may have contributed to the relatively older average age of household heads in our sample. Firstly, construction of new public housing in Israel ceased more than a decade ago and supply of units is highly constrained. At the same time, the low subsidized rental prices of public housing incentivize tenants to stay in their units. The combination of these factors may limit opportunities for younger households to enter the public housing system.

[21] This information does not imply that on average one-quarter of the units in each structure were sold to the tenants as in many occasions the government simply purchased a number of units within a condominium and turned them into public housing.

**Table 1B**
List of variables, definitions, and summary statistics for on-sample panel.

| Name | Variable definition | Avg. | Std. | Min | Max |
|---|---|---|---|---|---|
| $APPT\_VALUE_{i,t}$ ($) | Value of housing units translated to dollars | 86,879 | 31,223 | 18,286 | 265,161 |
| $RED_{i,t}$ | Current price reduction rate in percentage points | 45 | 34 | 0 | 95 |
| $RED_{i,t}\_DOLLAR_{i,t}$ | Current price reduction rate in US dollars | 38,936 | 32,967 | 0 | 196,712 |
| $ANCHOR_{i,t}$ | Accumulated average of all previous price reduction rates | 37 | 27 | 0 | 91 |
| $NEG_{i,t}$ | 1 − cases where $RED_{i,t} - ANCHOR_{i,t} < 0$; 0 – otherwise | 0.28 | 0.45 | 0 | 1 |
| $POS_{i,t}$ | 1 − cases where $RED_{i,t} - ANCHOR_{i,t} > 0$; 0 – otherwise | 0.51 | 0.50 | 0 | 1 |
| $(1 - NEG_{i,t}) \times (1 - POS_{i,t})$ | 1 − cases where $RED_{i,t} - ANCHOR_{i,t} = 0$; 0 − otherwise | 0.21 | 0.40 | 0 | 1 |
| $BENEFIT_i = RED\_DOLLAR_i - \frac{MR_i - SR_i}{r_t}\left[1-\frac{1}{(1+r_t)^{N_i}}\right]$ | The difference between subsidies embedded in purchase and rent | 27,593 | 38,415 | −125,336 | 196,712 |
| $YIELD\_STD_{i,t}$ | Standard deviation of monthly return of local housing price index in % points (estimated over a 3-year period prior to $t$) | 4 | 1 | 2 | 7 |
| $INCOME_i$ ($) | The level of annual current income in US dollars | 11,306 | 3975 | 879 | 42,045 |
| $MORTGAGE_t$ | Long-term annualized monthly mortgage rate in percentage points | 6.06 | 0.59 | 4.06 | 6.88 |
| $APPRECIATION_{i,t}$ | Annual appreciation of housing unit value in percentage points | 2.64 | 5.40 | −30.62 | 79.59 |
| $DURATION_{i,t}$ | Number of years in the public housing project | 22.78 | 9.94 | 0.67 | 51.83 |
| $CHILDREN_{i,t}$ | Number of children below 21 years for tenant $i$ at time $t$ | 2.55 | 1.63 | 1 | 11 |
| $DISABILITY_i$ | 1 − If at least one person in the household is physically-disabled<br>0 − Otherwise | 0.05 | 0.21 | 0 | 1 |
| $WHEELCHAIR_i$ | 1 − If the person or his spouse is confined to a wheelchair<br>0 − Otherwise | 0.01 | 0.12 | 0 | 1 |
| $MARRIED_i$ | 1 − Married<br>0 − Otherwise | 0.48 | 0.50 | 0 | 1 |
| $DIVORCED_i$ | 1 − Divorced<br>0 − Otherwise | 0.06 | 0.24 | 0 | 1 |
| $WIDOW_i$ | 1 − Widow<br>0 − Otherwise | 0.16 | 0.37 | 0 | 1 |
| $SINGLE\_PARENT_i$ | 1 − Single parent<br>0 − Otherwise | 0.15 | 0.35 | 0 | 1 |
| $SINGLE_i$ | 1 − Single<br>0 − Otherwise | 0.15 | 0.36 | 0 | 1 |
| $HEAD\_AGE_i$ | Age of the head of the household in years | 62.10 | 13.33 | 28 | 104 |
| $PUBLIC_i$ | Percentage of public housing units in the structure | 79.12 | 33.75 | 1.04 | 100.00 |
| $CONST\_AGE_i$ | Age of structure | 31.92 | 8.92 | 4.75 | 57.75 |
| $ELEVATOR_i$ | 1 − If there is an elevator in the structure<br>0 − Otherwise | 0.10 | 0.30 | 0 | 1 |
| $ENTRANCES_i$ | Number of entrances | 2.32 | 1.72 | 1 | 14 |
| $SHELTERS_i$ | Number of shelters | 0.33 | 0.53 | 0 | 2 |
| $FLOOR_i$ | The floor in which the housing unit is located | 2.22 | 1.54 | 0 | 15 |
| $FLOORS_i$ | The total number of floors in the structure | 3.85 | 1.87 | 1 | 16 |
| $ROOMS_i$ | Number of rooms | 3.21 | 0.80 | 1 | 9.5 |
| $AREA_i$ | The area of the housing unit in square feet | 797.53 | 172.70 | 215.28 | 1628.58 |
| $DETACHED_i$ | 1 − If the housing unit is one-story detached structure<br>0 − Otherwise | 0.08 | 0.27 | 0 | 1 |
| $HAIFA_i$ | 1 − If the location is in Haifa<br>0 − Otherwise | 0.05 | 0.22 | 0 | 1 |
| $NORTH_i$ | 1 − If the location is in the North<br>0 − Otherwise | 0.14 | 0.35 | 0 | 1 |
| $GUSH\_DAN_i$ | 1 − If the location is in Gush Dan<br>0 − Otherwise | 0.19 | 0.39 | 0 | 1 |
| $SOUTH_i$ | 1 − If the location is in the South<br>0 − Otherwise | 0.19 | 0.39 | 0 | 1 |
| $JERUSALEM_i$ | 1 − If the location is in Jerusalem<br>0 − Otherwise | 0.10 | 0.30 | 0 | 1 |
| $CENTER_i$ | 1 − If the location is in the center<br>0 − Otherwise | 0.15 | 0.36 | 0 | 1 |
| $KRAYOT_i$ | 1 − If the location is in the Krayot (near Haifa)<br>0 − Otherwise | 0.00 | 0.04 | 0 | 1 |
| $SHARON_i$ | 1 − If the location is in the Sharon<br>0 − Otherwise | 0.16 | 0.36 | 0 | 1 |
| $TEL\_AVIV_i$ | 1 − If the location is in the Tel Aviv<br>0 − Otherwise | 0.02 | 0.14 | 0 | 1 |

Note: Table 1B refers to the summary statistics of the primary on-sample variables across all time periods (excluding the date of purchase). The summary statistics of the variables $APPT\_VALUE_{i,t}$, $RED_{i,t}$, $BENEFIT_{i,t}$, $YIELD\_STD_t$, $MORTGAGE_t$, and $APPRECIATION_{i,t}$ refer to tenants occupying 6,853 purchased dwelling units ($i$= 1,2,...,6,853) across 314,840 time periods ($t$< = 0,1,..,113). The summary statistic of the *INCOME* variable refers to 1,002 households ($i$= 1,2,...,1,002) across 95,492 time periods. All the variables measured in *NIS* (the local Israeli currency) are converted to dollars, where 1 *NIS* roughly equals $0.25. The $\frac{MR_{i,t}-SR_{i,t}}{r_t}\left[1-\frac{1}{(1+r_t)^{N_{i,t}}}\right]$ variable measures the present value of rent subsidies given to public-housing tenants across all periods (excluding the date of purchase), $MR - SR$ is the difference between monthly market and subsidized rent, $r_t$ is the monthly yield on 1-year government bond (provided by the Bank of Israel) and $N$ is life expectancy in months based on the age of household head and life expectancy as published by the Israel Central Bureau of Statistics.
Note: The summary statistics of the variables $DURATION_{i,t}$, $CHILDREN_{i,t}$, $DISABILITY_i$, $WHEELCHAIR_i$, $MARRIED_i$, $DIVORCED_i$, $WIDOW_i$, $SINGLE\_PARENT_i$, $SINGLE_i$, $HEAD\_AGE_i$, $PUBLIC_i$, $CONST\_AGE_i$, $ELAVATOR_i$, $ENTRANCES_i$, $SHELTERS_i$, $FLOOR_i$, $FLOORS_i$, $ROOMS_i$, $AREA_i$, $DETACHED_i$, $HAIFA_i$, $NORTH_i$, $GUSH\_DAN_i$, $SOUTH_i$, $JERUSALEM_i$, *CENTER*, *KRAYOT*, *SHARON* and *TEL AVIV* refers to tenants occupying 6,853 purchased dwelling units ($i$= 1,2,...,6,853) across 314,840 time periods.

percent of the public housing units are detached. Finally, as indicated in Table 1B, the survival analysis includes locational controls.

## 5. Tests for anchoring: estimating tenant reaction to prior house price reductions

We now turn to assessment of whether purchase option exercise is conditioned on prior price reductions offered to tenants (controlling for current price reduction and other factors associated with option exercise). Below we develop and test a Cox Proportional Hazard model of tenant purchase option exercise. Consider the following model consisting of three structural equations:

$$\lambda(t) = \lambda_{00}(t)\exp\left[\alpha_1 ANCHOR_{i,t} + \alpha_2 RED_{i,t} + CONTROL \cdot \overline{\alpha}_3^T + \psi_{1,i,t}\right], \quad (1)$$

$$INCOME_i = X_1\delta_1 + \delta_2\left[\frac{\phi(z_i^*)}{\Phi(z_i^*)}\right] + u_{1,i}, \quad (2)$$

and

$$z_i^* = X_1\gamma_1 + X_2\gamma_2 + u_{2,i}, \quad (3)$$

where

$$\alpha_1 = \beta_1 NEG_{i,t} + \beta_2 POS_{i,t}, \quad (1.1)$$

$$\alpha_2 = \beta_3 NEG_{i,t} + \beta_4 POS_{i,t} + \beta_5\left(1-NEG_{i,t}\right)\left(1-POS_{i,t}\right), \quad (1.2)$$

$$\overline{\alpha}_3 = (\beta_6, \beta_7, \ldots, \beta_{10}), \quad (1.3)$$

$$\begin{aligned} CONTROL = {} & BENEFIT_{i,t},\ \Delta YIELD_S TD_t,\ PROJ(INCOME)_i, \\ & MORTGAGE_t,\ APPRECIATION_{i,t}\}. \end{aligned} \quad (1.4)$$

and where Eq. (1) is the hazard equation and Eqs. (2) and (3) are two auxiliary equations whose objective is to generate predicted values for the income variable in Eq. (1) as further explained below. Also, $t$ and $i$ represent time-period and household indices, respectively; $\lambda(t)$ is the hazard function, which captures the exercise rate of the option to purchase; $\lambda_{00}(t)$ is the baseline to the hazard function, which reflects variation over time in hazard risk at baseline levels of the covariates. The independent variables in Eq. (1) include $RED_{i,t}$, the current reduction rate on the dwelling price in percentage points and $ANCHOR_{i,t}$, the mean of all prior reduction rates excluding the current survival period computed separately for each household in every period. The full model includes interaction variables with $ANCHOR_{i,t}$: $ANCHOR_{i,t} \times NEG_{i,t}$ and $ANCHOR_{,i,t} \times POS_{i,t}$; and with $RED_{i,t}$: $RED_{i,t} \times NEG_{i,t}$, $RED_{i,t} \times POS_{i,t}$, and $RED_{i,t} \times (1 - POS_{i,t}) \times (1 - NEG_{i,t})$, where $NEG_{i,t}$ ($POS_{i,t}$) equals 1 if $RED_{i,t} - ANCHOR_{1,i,t} < 0$ ($RED_{i,t} - ANCHOR_{i,t} > 0$) and 0 otherwise.

The vector *CONTROL* in Eq. (1) includes a series of control variables that may correlate with the decision to exercise the purchase option. Among those, $BENEFIT_{i,t}$ is the return from exercising the purchase option at a discount net of the foregone present value of the expected rent subsidy derived from continuing to rent (expected to positively correlate with purchase option exercise); $\Delta YIELD\_STD_t$ is the first difference in the volatility of house price returns, capturing the risk in the underlying asset (e.g., Hull, 2011) and expected to negatively correlate with purchase option exercise[22]; $PROJ(INCOME)_i$ is the level of permanent income as generated from Eq. (2), which proxies for purchase affordability and thus is expected to be positively correlated with purchase option exercise; $\Delta MORTGAGE_t$ is the first difference in monthly mortgage rates (between periods $t$ and $t-1$), reflecting the financing cost of the transaction and accordingly expected to negatively correlate with purchase option exercise; and $APPRECIATION_t$ represents the annual rate of appreciation in the housing unit over time, reflecting the expected capital gain from purchasing the unit and as such is expected to positively correlate with purchase option exercise (e.g., Mills and Hamilton, 1994). Finally, $\beta_1, \ldots, \beta_{10}$ are the estimated coefficients associated with Eq. (1) and $\psi_{1i,t}$ is the random disturbance term.

The specification of Eq. (1) is designed to capture the responses of tenants to the anchor vis-à-vis the current reduction rate in the case that: 1) the anchor is greater than the current reduction rate; 2) the anchor is lower than the current reduction rate; and 3) the anchor is equal to the current reduction rate. Following the seminal study of loss aversion by Kahneman and Tversky (1979), when the current reduction rate is lower than the anchor ($RED_{i,t} - ANCHOR_{i,t} < 0$, i.e., $NEG = 1$), an increase in the anchor, ceteris paribus, may be interpreted as a greater loss compared to the reference reduction rate (i.e., the anchor). Alternatively, when the current reduction rate is greater than the anchor ($RED_{i,t} - ANCHOR_{i,t} > 0$, i.e., $POS = 1$), an increase in the anchor, ceteris paribus, still offers a gain in the current reduction rate (compared to the reference reduction rate, i.e., the anchor).[23] If tenants are unresponsive to the anchor, we expect that $\beta_1 = \beta_2 = 0$, namely, that the decision of the tenant is affected only by the current reduction rate, but not by the anchor.

As noted above, in estimating Eq. (1), we focus only on the sample of 6,853 purchasing households over a timeframe of up to 114 months so as to avoid possible attribution of non-purchase as an anchoring effect rather than due to affordability constraints or other considerations.

The model specification also includes auxiliary Eqs. (2) and (3) whose objective is to generate predicted values of the income variable in Eq. (1) and to account for possible sample selection of buyers in Eq. (1) due to possible correlation between affordability of dwelling units and the decision to purchase. As described below, in auxiliary Eqs. (2) and (3) we address potential selection bias using the Heckman two-step selection procedure.[24]

In the estimation of Eq. (3) we employ the full sample of 58,665 households who either purchased or did not purchase during the sample period. The dependent variable in Eq. (3), $z_i^*$, is a binary variable that receives a value of 1 in the case that the tenant reported the level of income and 0 otherwise (see footnote 17). The $X$ matrices control for socio-demographic and regional dummies ($X_1$) and dwelling characteristics ($X_2$) whereas $\gamma_1$ and $\gamma_2$ are vectors of parameters and $u_2$ is a random disturbance term. Note that Eqs. (2) and (3) are specified so as to ensure that $\delta_1$, the vector of parameters in Eq. (2), is statistically identified.[25]

Eq. (2) is estimated using the sample of 35,825 households for whom current income is not censored, where the dependent variable in Eq. (2) is the level of current income, $INCOME_i$. The functions $\phi(z_i^*)$ and $\Phi(z_i^*)$ are the normal density and the cumulative normal density,

[22] Originally, we calculated $YIELD\_STD_t$ as the 3-year standard deviation of annual price returns on the local housing price index (corresponding to the location of the housing unit). For this time-varying and non-stationary series the unit root hypothesis is not rejected (MacKinnon approximate p-value of 39.40%). The unit root hypothesis similarly is not rejected for $MORTGAGE_t$ (MacKinnon approximate p-value of 87.74%). We thus specify these non-stationary control variables in difference terms. The $APPRECIATION_t$ series is found to be stationary (unit-root hypothesis is rejected at the 5% level).

[23] As first described by Kahneman and Tversky (1979), loss aversion pertains to household behavior when "the aggravation that one experiences in losing a sum of money appears to be greater than the pleasure associated with gaining the same amount" (page 279).

[24] For further discussion of correction for sample selection in panel-data analysis see, Wooldridge (2002).

[25] As modeled in Eq. (3), a higher rent level (correlating with the dwelling's physical characteristics) may encourage tenant's decision to file an income report in order to maintain the rent subsidy—hence, the incorporation of the matrix $X_2$ on the right-hand side of Eq. (3). There is no reason, however, to expect that the public dwelling's characteristics also correlate with the income level in Eq. (2). In contrast, household socio-demographic characteristics ($X_1$) may be expected to correlate with both the income level and the decision to report income. The specific variables included in $X_1$ and $X_2$ arise from data availability.

**Table 2**
Testing for anchoring effects using Cox regressions.

| | Denoted | Percentage<br>Restricted | Percentage<br>Unrestricted | Thousands of dollars<br>Unrestricted |
|---|---|---|---|---|
| *Coefficient of:* | | | | |
| $ANCHOR_{i,t} \times NEG_{i,t}$ | $\beta_1$ | – | $-0.08^{***}$ | $-0.15^{***}$ |
| | | – | (0.01) | (0.01) |
| $ANCHOR_{i,t} \times POS_{i,t}$ | $\beta_2$ | – | $0.01^{***}$ | $0.02^{***}$ |
| | | – | $(1.03 \times 10^{-3})$ | $(9.73 \times 10^{-4})$ |
| $RED_{i,t} \times NEG_{i,t}$ | $\beta_3$ | $0.03^{***}$ | $0.10^{***}$ | $0.16^{***}$ |
| | | $(1.39 \times 10^{-3})$ | (0.01) | (0.01) |
| $RED_{i,t} \times POS_{i,t}$ | $\beta_4$ | $0.03^{***}$ | $0.01^{***}$ | $-0.01^{***}$ |
| | | $(7.81 \times 10^{-4})$ | $(1.18 \times 10^{-3})$ | $(1.33 \times 10^{-3})$ |
| $RED_{i,t} \times (1 - NEG_{i,t}) \times (1 - POS_{i,t})$ | $\beta_5$ | $0.04^{***}$ | $0.03^{***}$ | $0.02^{***}$ |
| | | $(2.56 \times 10^{-3})$ | $(2.56 \times 10^{-3})$ | $(3.70 \times 10^{-3})$ |
| $BENEFIT_{i,t}$ | $\beta_6$ | $8.15 \times 10^{-6***}$ | $9.12 \times 10^{-6***}$ | $1.97 \times 10^{-5***}$ |
| | | $(4.71 \times 10^{-7})$ | $(4.85 \times 10^{-7})$ | $(1.27 \times 10^{-6})$ |
| $\Delta YIELD\_STD_t$ | $\beta_7$ | 0.10 | 0.11 | 0.05 |
| | | (0.25) | (0.24) | (0.24) |
| $PROJ(INCOME)_i$ | $\beta_8$ | $-2.75 \times 10^{-5***}$ | $-4.63 \times 10^{-5***}$ | $8.95 \times 10^{-5***}$ |
| | | $(6.66 \times 10^{-6})$ | $(6.87 \times 10^{-6})$ | $(6.66 \times 10^{-6})$ |
| $\Delta MORTGAGE_t$ | $\beta_9$ | 0.50 | 0.39 | 0.62 |
| | | (0.76) | (0.77) | (0.83) |
| $APPRECIATION_{i,t}$ | $\beta_{10}$ | $0.01^{***}$ | $0.01^{***}$ | 0.01 |
| | | $(4.14 \times 10^{-3})$ | $(4.14 \times 10^{-3})$ | $(4.10 \times 10^{-3})$ |
| *Regression statistics:* | | | | |
| *MONTHS × SUBJECTS* | | 314,797 | 314,797 | 314,797 |
| *SUBJECTS* | | 6,853 | 6,853 | 6853 |
| *LR STATISTICS* | | 5,139 | 5,403 | 4758 |
| *LOG LIKELIHOOD* | | −51,401 | −51,269 | −51,592 |
| *Calculated Chi-square* | | | | |
| Anchoring hypothesis: | $\beta_1 = \beta_2 = 0$ | – | $211.06^{***}$ | $495.22^{***}$ |

Notes: The table displays the results of estimation of the Cox Proportional Hazard model. The sample consists of an unbalanced panel of public housing tenants indexed as $i = 1,\ldots,6{,}853$. We follow their behavior across time, where the time index ($t$< 0,1,..,114) is given in months and covers the period of 1999–2008. The dependent variable in the model is the level of hazard to survival. The $ANCHOR_{i,t}$ variable, calculated for each household separately, is the mean of all prior reduction rates excluding the current survival period. The full model includes interaction variables with $ANCHOR_{i,t}$: $ANCHOR_{i,t} \times NEG_{i,t}$ $ANCHOR_{i,t} \times POS_{i,t}$, and with $RED_{i,t}$: $RED_{i,t} \times NEG_{i,t}$, $RED_{i,t} \times POS_{i,t}$, and $RED_{i,t} \times (1 - POS_{i,t}) \times (1 - NEG_{i,t})$, where $NEG_{i,t}$ ($POS_{i,t}$) equals 1 if $RED_{i,t} - ANCHOR_{1,i,t} < 0$ ($RED_{i,t} - ANCHOR_{i,t} > 0$) and 0 otherwise. These variables are measured in percentages (thousand of dollars) in the left two columns (right column). The *BENEFIT* variable measures the dollar difference between discounted purchase subsidy (*RED_DOLLAR*) and rent subsidy ($\frac{MR_{i,t} - SR_{i,t}}{r_t}\left[1 - \frac{1}{(1+r_t)^{N_{i,t}}}\right]$). All the regressions incorporate the variable *PROJ*(*INCOME*), the projected values of the current income obtained from the Heckman two-step selection procedure and translated to dollars. This procedure is applied to the full sample of renters and buyers and addresses the problems of censored income and selection bias. Standard errors are given in parentheses. * significant at a level of 10%, ** significant at a level of 5% and *** significant at a level of 1%.

respectively, of the likelihood to report the level of income and $\frac{\phi(z_i^*)}{\Phi(z_i^*)}$, the inverse-mills ratio, which is estimated as the projected probability of $z_i^*$ obtained from the probit regression in Eq. (3). The full set of outcomes from the estimation of auxiliary Eqs. (2) and (3) is given in Appendix D.[26]

Eqs. (2) and (3) address three potential concerns regarding the dataset. The first is that current income may be a poor proxy for permanent income. The second is that the *INCOME* term is censored for reasons specified earlier (see footnote 25). Thirdly, our sample of purchasers may be subject to selection bias due to difficulties among low-income renter households in affording and financing the purchase of a dwelling unit. Consequently, the Heckman correction is required. Because the level of income is also positively correlated with the decision to buy the dwelling unit, the use of the latter decision as the selection criteria is appropriate.[27] Finally, note that as the estimation of the *INCOME* term derives from a long list of individual socio-demographic, regional, and dwelling characteristics, the two-step procedure substantially controls for heterogeneity in individual-level preferences for home purchase (results obtained from this first-step procedure are given in Appendix D).

In sum, based on the Heckman selection procedure, we generate a vector of projected income values, which allows us to compute the permanent income of each tenant in the full sample. We then incorporate this vector into the unbalanced panel of 6853 buyers. In this manner, we address the negative incentive of high-income tenants to report

[26] In order to simultaneously address the possible selection bias of both the decision not to purchase the dwelling and not to report the income level, we also applied in Eq. (3) an extension of Heckman's correction proposed by Dubin and McFadden (1984), where the dependent variable maintained three categories: 0 for tenants who did not report their level of income (base category); 1 for tenants who reported their level of income but did not purchase the unit; and 2 for tenants who both reported income level and purchased the unit. This procedure produced two variables $M_0$ – reflecting the selection bias with respect to the decision to purchase, and $M_1$ – reflecting the selection bias with respect to the decision not to report the level of income. Results of this procedure, however, revealed an insignificant coefficient on $M_0$ (−581.77 and standard error of 414.55) and a significant coefficient of $M_1$ at the 1% level (1046.77 and standard error of 392.07). This outcome thus supported the correction for selection bias related only to the decision not to report the income level. Moreover, the outcomes obtained from the estimation of Eq. (1) following this procedure do not change. Results from this procedure are available upon request.

[27] The positive and significant Inverse-Mills ratio obtained in the estimation procedure (estimated coefficient of 1164 and standard error of 135.90) supports the hypothesis of selection bias addressed via this procedure (see Appendix D for further details). Also, current annual income of purchasers turns out to be \$1950.85 higher than non-purchasers – the difference is significant at the 1%-level (calculated $t$-value equals 24.93).

their income level. Further, we address the concern that current income may be a poor proxy for permanent income.

## 6. Results

Table 2 presents results of regression analysis that tests for the presence of anchoring in tenant decisions to exercise the home purchase option. The outcomes in the left-hand column of Table 2 [where $RED_{i,t}$ is interacted with $NEG_{i,t}$, $POS_{i,t}$, and $(1 - NEG_{i,t}) \times (1 - POS_{i,t})$, with $RED_{i,t}$ measured in percentage points] demonstrate the expected behavioral pattern in the case that the restrictions $\beta_1 = \beta_2 = 0$ are imposed. In that regard, tenants appear to be highly aware of the current price reduction rate. Indeed, the significant coefficients on the three variables interacted with $RED_{i,t}$ indicate that a 1% rise in the price reduction rate increases the hazard to exercise by 3–4%.

The unrestricted model (the middle and right columns) incorporates the interactions of both *RED* and *ANCHOR* with *NEG* and *POS*. While the middle column refers to outcomes obtained in the case where *ANCHOR* and *RED* are measured in percentage points, the right-hand column refers to outcomes obtained in the case where *ANCHOR* and *RED* are measured in nominal dollar terms. Empirical findings provide solid evidence in support of the anchoring heuristic. The restricted model is statistically rejected in favor of the unrestricted model (which includes the anchoring variables): each of the coefficients on $ANCHOR_{i,t} \times NEG_{i,t}$ ($\beta_1$) and $ANCHOR_{i,t} \times POS_{i,t}$ ($\beta_2$) are significant at the 1% level.[28] Specifically, for the percentage point specification, the estimated coefficients on $ANCHOR_{i,t} \times NEG_{i,t}$ and $ANCHOR_{i,t} \times POS_{i,t}$ imply that a 1% increase in the *ANCHOR* term leads to an 8% reduction and a 1% rise in the hazard to exercise in the cases that $NEG = 1$ and $POS = 1$, respectively. Similarly, for the nominal dollar specification, the estimated coefficient on $ANCHOR_{i,t} \times NEG_{i,t}$ and $ANCHOR_{i,t} \times POS_{i,t}$ indicates that a \$1000 increase in the *ANCHOR* leads to a 15% decline and a 2% rise in the hazard to exercise in the cases that $NEG = 1$ and $POS = 1$, respectively.

Finally, the estimated coefficients of the control variables are as follows: All things equal, purchase option exercise is elevated among tenants with a higher net subsidy to purchase, as a 1000 dollar increase in the net benefit associated with option purchase exercise (*BENEFIT*) leads to a significant 1–2% increase in the hazard to exercise. In addition, an increase in house price appreciation significantly accelerates home purchase. Finally, somewhat surprisingly, an increase in our proxy for tenant permanent income serves to defer purchase option exercise.[29]

## 7. Simulation of anchoring effects

In this section we utilize the Cox Proportional Hazard Model estimates to further demonstrate the economic significance of the anchoring heuristic. Specifically, we simulate the response of tenants to *hypothetical* ascending and descending reduction rate schemes and compare the average time to purchase option exercise and the average price reduction rate at time of exercise. Further, we undertake that analysis in the case of both the restricted and unrestricted models (i.e., with and without $ANCHOR_{i,t} \times NEG_{i,t}$ and $ANCHOR_{i,t} \times POS_{i,t}$ in the model).

Specifically, we reconstruct the original panel to produce two time-series of reduction rates for each household – one that is monotonically non-decreasing (hereafter, ascending) and the other that is monotonically non-increasing (hereafter, descending). Using the estimated coefficients of the model specified in Eqs. (1)–(3), we then predict the response of public housing tenants to the two hypothetical reduction schemes. Further, we compute the average number of months until exercise across all households and the average price reduction rate at the time of exercise for each reduction scheme and across all households. The anchoring heuristic is supported to the extent that tenants exhibit statistically different responses to restricted and unrestricted specifications of the price reduction rate schemes.

Results of the simulation exercise further demonstrate the importance of the anchoring heuristic.[30] As shown in Fig. 1, the average projected number of months until exercise generated from the unrestricted model (which includes the *ANCHOR* variables) is 68 months under the ascending scheme and 24 months under the descending scheme. In contrast, the respective figure generated from the restricted model (which excludes the *ANCHOR* variables) is 86 months under both the ascending and descending schemes. The 62-month (18-month) difference associated with the descending (ascending) scheme is significant at the 1% level (respective calculated *t*-values of 10.14 and 13.99). Moreover, under the descending pattern, results of the restricted model severely understate the average exercised reduction rate – only 16% compared to 48% in the unrestricted model. This 32% difference is significant at the 1% level (calculated *t*-value of 32.54).

Fig. 1 also allows us to compare the actual versus simulated values for average number of months until option exercise and average

[28] Furthermore, the null hypothesis that $\beta_1 = \beta_2 = 0$ (i.e., that tenants do not respond to the anchor either under $NEG = 1$ or $POS = 1$) is rejected at the 1%-level (calculated chi-square values of 211.06 and 495.22, respectively). Also, the smaller log-likelihood of the nominal dollar model compared to the percentage point model (−51,592 compared to −51,269) indicates a somewhat better fit of the latter model (i.e., when reduction rates are measured in percentage points). This is further consistent with the fact that according to the guidelines of the Ministry of Housing and Construction, reduction rates are computed in percentage points rather than dollar values.

[29] Recall, however, that the positive correlation between permanent income and the likelihood to defer the purchase applies only to our examined sample of purchasers as we excluded non-purchasers from the estimation of Eq. (1). Moreover, the estimated coefficient on the income variable is not economically significant.

[30] To compute the average number of months until purchase option exercise and the average reduction rate at the time of exercise (across all households), we estimate two versions of the Cox Proportional Hazard model for all $k$, $k = (ascending, descending)$, and use it to predict the survival rates at the sample mean. The unrestricted model is given by:

$$\begin{aligned}\lambda(t) = \lambda_{01}(t)\exp\Big[&\omega_1\left(ANCHOR_{Original,i,t} - ANCHOR_{k,t}\right) \times NEG_{i,t} \\ &+ \omega_2\left(ANCHOR_{Original,i,t} - ANCHOR_{k,t}\right) \times POS_{i,t} + \omega_3\left(RED_{Original,i,t} - RED_{k,t}\right) \times NEG_{i,t} \\ &+ \omega_4\left(RED_{Original,i,t} - RED_{k,t}\right) \times POS_{i,t} + \omega_5\left(RED_{Original,i,t} - RED_{k,t}\right) \times (1 - NEG_{i,t}) \\ &\times (1 - POS_{i,t}) + \omega_6(BENEFIT_{i,t} - 60,569.01) + \omega_7\left(\Delta APPT\_YIELD\_STD_t - 5.54 \times 10^{-2}\right) \\ &+ \omega_8(PROJ(INCOME)_i - 9,429.86) + \omega_9\left(\Delta MORTGAGE_t + 8.96 \times 10^{-2}\right) \\ &+ \omega_{10}(APPRECIATION_t - 0.88) + \psi_{3,i,t}\Big],\end{aligned}$$

where $k = (ascending, descending)$ represents the constructed ascending and descending price reduction rate schemes, *Original* stands for the actual reduction rate scheme and all other variables are as above described in Table 1B. The restricted model is obtained by imposing the restriction $\omega_1 = \omega_2 = 0$. Again, the control explanatory variables are expressed in terms of deviations from the sample mean and the specification of the model includes Eqs. (2) and (3) as above. We thus produce two vectors of projected survival rates [i.e. for $k = (ascending, descending)$]. We compute the average number of months until exercise across all households by

$$\sum_{t=1}^{114}\left\{\left[PROJ(\text{survival rates})_{k,t} - PROJ(\text{survival rates})_{k,t-1}\right] \times t\right\},$$

where $PROJ(survival\ rates)_{k,t}$ is the projected survival rate at time $t$ for the ascending and descending schemes. We also compute the projected average reduction rate at exercise across all households by

$$\sum_{t=1}^{114}\left[PROJ(\text{survival rates})_{k,t} - PROJ(\text{survival rates})_{k,t-1}\right] \times RED_{Exercised,k,t}$$

where $RED_{Exercised,k,t}$ is the average reduction rate across all households who purchased at month $t$ ($t = 0,\ldots,114$) ordered in ascending/descending patterns.

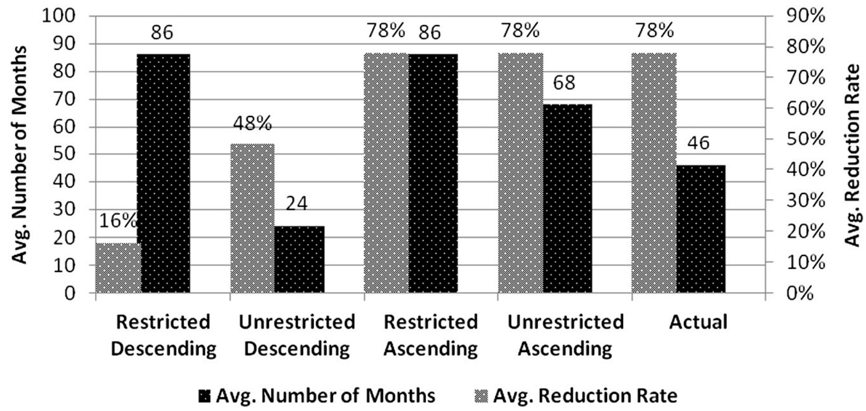


**Fig. 1.** Average exercised reduction rates and number of months until option exercise across descending, ascending, and actual reduction rate schemes. Notes: The ascending and descending schemes were generated by sorting the actual reduction rates each tenant faces. We computed the exercised reduction rates under the ascending (descending) schemes as: $\sum_{t=0}^{114} PROJ(\text{exercise\_rates}) \times REDUCT\_PER(fail = 1)$, where $PROJ(\text{exercise\_rates})$ is calculated from the projected survival rates for $t = 0,\ldots,114$ obtained from the Cox Regression and $REDUCT\_PER(fail = 1)$ is the average reduction rate across all households who purchased at month $t$ ($t = 0,\ldots,114$) under the ascending (descending) scheme. %%%% We calculated the average number of months until exercise as $\sum_{t=0}^{114} PROJ(\text{exercise\_rates}) \times t$ where $PROJ(\text{exercise\_rates})$ is calculated from the projected survival rates obtained from the Cox Regression and $t$ is the time index in months ($t = 0,\ldots,114$).

reduction rate at time of exercise. Those values are computed for both the ascending and descending schemes in the case of the unrestricted model (that is, including the *ANCHOR* variable). It follows from the figure that while the actual number of months until exercise is 46, that value rises to 68 months and declines to 24 months under the ascending and descending reduction rate patterns, respectively. The 22-month difference between the actual and descending (ascending) schemes is statistically significant at the 1% (10%) level ($t$-value equals 6.32 and 1.89, respectively).

Finally, the average reduction rate at the time of purchase option exercise declines from 78% under the ascending scheme to 48% under the descending scheme (compared with 78% under the actual reduction rate pattern). The 30 percentage point difference between the ascending and descending schemes is

**Table 3**
Testing the interaction of the anchoring effect with $AGE_{i,t}$, $PROJ\_INC_i$, and $PUBLIC_i$.

| Coefficient of: | Denoted | $AGE_{i,t}$ | $PROJ\_INC_i$ | $PUBLIC_i$ |
|---|---|---|---|---|
| $ANCHOR_{i,t} \times NEG_{i,t}$ | $\theta_1$ | $-0.17^{***}$ | $0.10^{***}$ | $-0.16^{***}$ |
| | | (0.03) | (0.03) | (0.03) |
| $ANCHOR_{i,t} \times POS_{i,t}$ | $\theta_2$ | $0.02^{***}$ | $-1.51 \times 10^{-3}$ | $0.02^{***}$ |
| | | $(3.19 \times 10^{-3})$ | $(4.12 \times 10^{-3})$ | $(1.70 \times 10^{-3})$ |
| $ANCHOR_{i,t} \times NEG_{i,t} \times V_{i,t}$ | $\theta_3$ | $1.67 \times 10^{-3***}$ | $-1.88 \times 10^{-5***}$ | $9.52 \times 10^{-4***}$ |
| | | $(4.59 \times 10^{-4})$ | $(3.71 \times 10^{-6})$ | $(3.15 \times 10^{-4})$ |
| $ANCHOR_{i,t} \times POS_{i,t} \times V_{i,t}$ | $\theta_4$ | $-1.38 \times 10^{-4***}$ | $1.16 \times 10^{-6***}$ | $-6.28 \times 10^{-5***}$ |
| | | $(5.24 \times 10^{-5})$ | $(4.07 \times 10^{-7})$ | $(1.74 \times 10^{-5})$ |
| $RED_{i,t} \times NEG_{i,t}$ | $\theta_5$ | $0.25^{***}$ | $0.12^{***}$ | $0.20^{***}$ |
| | | (0.03) | (0.03) | (0.03) |
| $RED_{i,t} \times POS_{i,t}$ | $\theta_6$ | $0.02^{***}$ | $-1.31 \times 10^{-3}$ | $0.02^{***}$ |
| | | $(3.44 \times 10^{-3})$ | $(4.48 \times 10^{-3})$ | $(1.90 \times 10^{-3})$ |
| $RED_{i,t} \times (1 - NEG_{i,t}) \times (1 - POS_{i,t})$ | $\theta_7$ | $0.12^{***}$ | $3.39 \times 10^{-3}$ | $0.04^{***}$ |
| | | (0.01) | (0.02) | (0.01) |
| $RED_{i,t} \times NEG_{i,t} \times V_{i,t}$ | $\theta_8$ | $-2.47 \times 10^{-3***}$ | $2.37 \times 10^{-5***}$ | $1.11 \times 10^{-3***}$ |
| | | $(4.98 \times 10^{-4})$ | $(3.88 \times 10^{-6})$ | $(3.28 \times 10^{-4})$ |
| $RED_{i,t} \times POS_{i,t} \times V_{i,t}$ | $\theta_9$ | $-1.51 \times 10^{-4***}$ | $1.65 \times 10^{-6***}$ | $-3.79 \times 10^{-5*}$ |
| | | $(5.66 \times 10^{-5})$ | $(4.56 \times 10^{-7})$ | $(2.06 \times 10^{-5})$ |
| $RED_{i,t} \times (1 - NEG_{i,t}) \times (1 - POS_{i,t}) \times V_{i,t}$ | $\theta_{10}$ | $-1.67 \times 10^{-4***}$ | $2.97 \times 10^{-6}$ | $-9.34 \times 10^{-5}$ |
| | | $(3.07 \times 10^{-4})$ | $(2.15 \times 10^{-6})$ | $(1.06 \times 10^{-4})$ |
| $V_{i,t \text{ or } V_i}$ | $\theta_{11} - \theta_8$ | $0.02^{***}$ | $-2.38 \times 10^{-4***}$ | $0.01^{***}$ |
| | | $(3.62 \times 10^{-3})$ | $(3.00 \times 10^{-5})$ | $(1.45 \times 10^{-3})$ |

Notes: The table displays the survival analysis outcomes obtained by employing the Cox Proportional Hazard model. The sample contains an unbalanced panel of public housing tenants indexed as $i = 1,\ldots,6{,}853$. We follow their behavior across time, where the time index ($t< 0,1,..,114$) is given in months and covers the period of 1999–2008. The tenants fail to survive ($\text{failure} = 1$) and are excluded from the sample when they decide to exercise the purchase. The dependent variable in the model is the level of hazard to survival. We run the Cox regression separately on the following explanatory variables: $V_{i,t} = AGE_{i,t}$(age of the head of household in years), and $V_i = PROJ\_INC_i$ (annual projected income measured in US Dollars) and $PUBLIC_i$ (percentage of public housing units the structure). The $ANCHOR_{i,t}$ variable, which was calculated for each household separately, is the mean of all prior reduction rates excluding the current survival period. The full model includes interaction variables with $ANCHOR_{i,t}$: $ANCHOR_{i,t} \times NEG_{i,t}$; $ANCHOR_{i,t} \times POS_{i,t}$; $ANCHOR_{i,t} \times NEG_{i,t} \times V_{i,t\ (Vi)}$; $ANCHOR_{i,t} \times POS_{i,t} \times V_{i,t\ (Vi)}$; and with $RED_{i,t}$: $RED_{i,t} \times NEG_{i,t}$; $RED_{i,t} \times POS_{i,t}$; $RED_{i,t} \times (1 - POS_{i,t}) \times (1 - NEG_{i,t})$; $RED_{i,t} \times NEG_{i,t} \times V_{i,t\ (Vi)}$; $RED_{i,t} \times POS_{i,t} \times V_{i,t\ (Vi)}$; and $RED_{i,t} \times (1 - POS_{i,t}) \times (1 - NEG_{i,t}) \times V_{i,t\ (Vi)}$, where $NEG_{i,t}$ ($POS_{i,t}$) equals 1 if $RED_{i,t} - ANCHOR_{1,i,t} < 0$ ($RED_{i,t} - ANCHOR_{i,t} > 0$) and 0 otherwise. All the regressions incorporate additional control variables, which their estimated coefficients are not reported here. Standard errors are given in parentheses. * significant at a level of 10%, ** significant at a level of 5% and *** significant at a level of 1%.

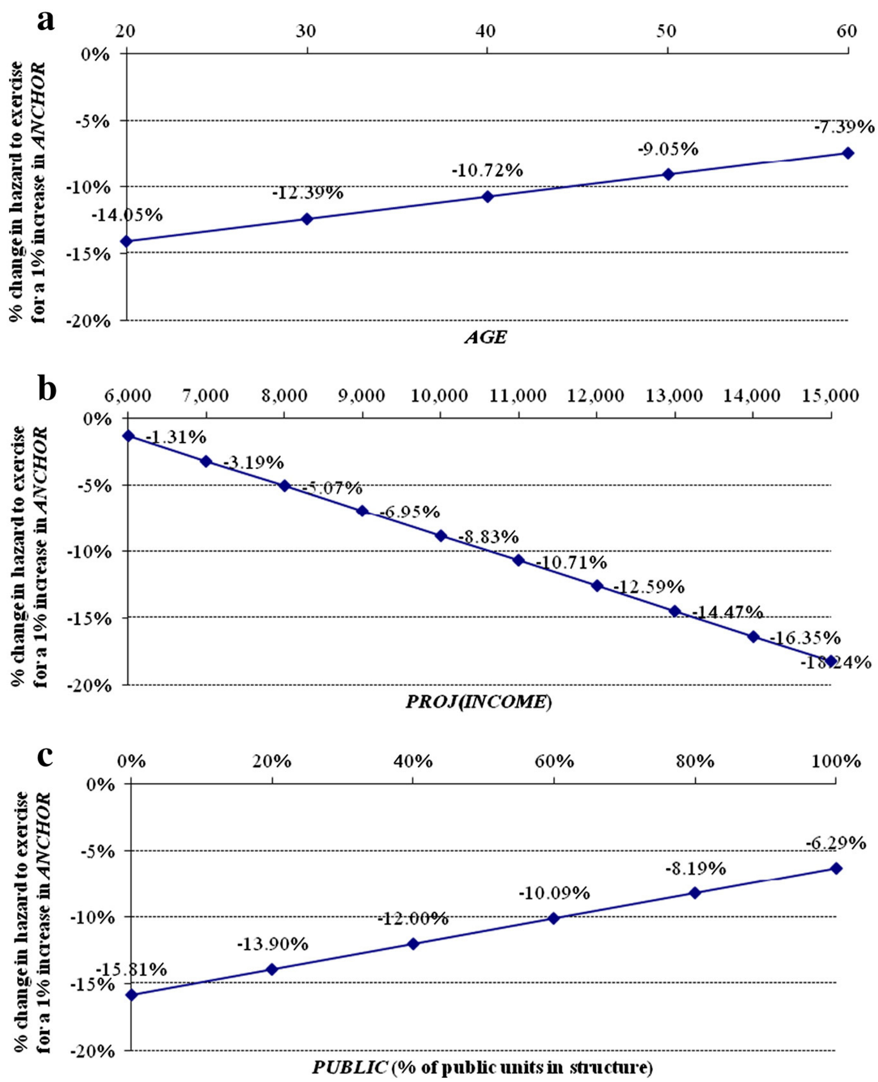


**Fig. 2.** a: The effect of 1% increase in the anchor on the hazard to exercise for different levels of $AGE_{i,t}$ (when $NEG_{i,t} = 1$). b: The effect of 1% increase in the anchor on the hazard to exercise for different levels of $PROJ\_INC_i$ (when $NEG_{i,t} = 1$). c: The effect of 1% increase in the anchor on the hazard to exercise for different levels of $PUBLIC_i$ (when $NEG_{i,t} = 1$).

statistically significant at the 1% level (absolute $t$-value equals 4.75) and the 30% difference between the actual and the descending schemes is statistically significant at the 1% level ($t$-value equals 10.16).

Intuitively, this outcome directly arises from the outcomes in Table 2. Note the opposing effects at work in our constructed descending reduction rate pattern: On one hand, the tenant can no longer buy the unit for as low a price as she could in the past, yielding a propensity to postpone the purchase. This is captured in the coefficient on $ANCHOR \times NEG$, which is equal to $-0.08$ in Table 2. On the other hand, however, ceteris paribus, the greater the current reduction rate, the more likely that one exercises the purchase option. This is captured by the coefficient on $RED \times NEG$ that is equal to 0.10 in Table 2. In the case that the latter force more than offsets the former, the tenant tends to exercise the purchase relatively early under the descending pattern.

Results of the simulation exercise accordingly provide further evidence of the economic significance of the *ANCHOR* term in assessment of purchase option exercise. Moreover, outcomes of this exercise carry considerable implications for program management. By taking account of anchoring behavior among tenants of public housing, Israeli government officials could both have accelerated the sale of public housing units and reduced the average price reduction rate at time of purchase. Had the government offered equivalent reduction rates, in a descending pattern, the average time-to-exercise would have declined by 22 months and revenues from sale would have increased by 30%.[31]

[31] Of course, any number of price reduction schemes could have been offered by the government. The above price reduction scheme is offered solely for the purpose of demonstrating possible benefits to government program execution associated with an explicit accounting of the anchoring heuristic. Examination of the efficiency effects of the one pattern or another is beyond the scope of our analysis. Of course, in order to implement a non-random walk reduction rate scheme, program managers must maintain the confidentiality of the planned reduction rate pattern as households would otherwise be able strategically exercise the purchase option.

## 8. Robustness tests

In Section 3 above, we addressed the possibility that tenants could have collected information on the likelihood of future reduction rates so as to strategically exercise the purchase option. Test results indicated that all price reduction time-series follow a random walk. Here we augment those findings in assessment of whether timing of dwelling purchase varied systematically with the national election cycle and the Israeli government coalition in power. Specifically, households may have used information on the social policy and privatization agendas of various Israeli governments to infer level of support for and hence generosity of housing privatization regimes. To assess this possibility, we include dummy variables in the Cox regression for the different Israeli government coalitions in power during the sample period. Note that the term in office of coalition governments in Israel is highly variable and hence difficult to forecast (in fact, one coalition government in our sample period survived only 1-1/2 years prior to new elections). Moreover, due to the high cost of the housing privatization program, some coalition governments opposed the program (indeed, the privatization program was terminated following the end of our sample period). Results of those analyses yielded insignificantly different purchase option coefficients across different government regimes (LR calculated statistic of 0.68 with 2 degrees of freedom and $p$-value of 71.21%). It is doubtful that program participants could have predicted either the stability of the governments in power or their specific approaches to the price reduction schemes.

In a further robustness test, we run a Cubic-Spline Cox Proportional Hazard model to account for business cycles and crisis subperiods within the sample period. Those crisis sub-periods included the second Palestinian uprising (Intifada), three major large scale military operations (including the second Lebanon war) and external events such as the recent global financial crisis. Results of the Cox Proportional Hazard model are robust to business cycle and crisis period effects as the hypotheses that $\beta_1 = 0$ and $\beta_2 = 0$ are rejected at the 1% significance level (respective calculated $t$-values of $-7.28$ and 21.70).[32]

## 9. Are anchoring results robust to individual characteristics?

In the above analysis, we provide evidence in support of price anchoring in timing of home purchase. A remaining question, however, is whether anchoring varies with individual and economic characteristics. Genesove and Mayer (2001) and List (2003, 2004, 2011), for example, provide evidence that anchoring varies with individual experience. Along similar lines, below we report on tests of whether the anchoring heuristic varies with individual factors such as the age of the household head (*AGE*), household income (*PROJ_INC*), and the percentage of public housing units in the structure (*PUBLIC*).

Appendix E shows the methodology we use to test the effect of the interaction of the anchoring variable with *AGE*, *PROJ_INC*, and *PUBLIC*. Table 3 reports the results of this test. Those results provide evidence of significant individual variation in anchoring heuristics. In both cases where $RED - ANCHOR < 0$ and $RED - ANCHOR > 0$ (i.e., when $NEG = 1$ and $POS = 1$, respectively), the coefficients on the above interaction terms are significant at the 1% level.

Fig. 2A–C plots the marginal effect of an increase in the anchor by one unit (i.e., 1%) on the hazard to exercise for different levels of the interaction variable for $NEG = 1$.[33] It follows that age of household head (*AGE*) moderates the anchoring effect: while a 1% increase in the anchor for a 20 year old leads to a 14% drop in the hazard to exercise, the equivalent decrease in the hazard to exercise for a 60-year old is only 7%. We also find that income positively correlates with the anchoring effect: increasing the anchor by 1% when annual income equals 6,000 dollars leads to only a 1.31% decline in the hazard to exercise, whereas increasing the anchor by 1% when annual income equals 15,000 dollars results in a full 18% reduction in the hazard rate of option exercise.[34]

Finally, an increase in the percentage of public units in the structure diminishes the effect of the anchor. Increasing the anchor by 1% when all other units in the structure are privately owned results in a 16% drop in the hazard to exercise, whereas the equivalent drop in the hazard to exercise is only 6% when all other dwelling units in the building are publically-owned. This finding indicates that potential buyers may also use the reduction rates offered to tenants in the structure as possible anchors, thereby moderating the effect of their own past offered reduction rates as the anchor in exercising the purchase option.

## 10. Summary and conclusion

This research provides new empirical evidence on the role of anchoring in timing of home purchase. The analysis employs a unique dataset from a natural policy experiment designed to privatize public housing in Israel. The government programs, which date from 1999, provided public housing tenants with a call (real) option to purchase their dwelling unit at a discounted exercise price.

Statistical findings indicate the importance of the anchoring heuristic in timing of program uptake. Simulated government offer price reduction schemes show that in retrospect, by accounting for the anchoring heuristic, government program managers could both have accelerated the sale of public housing units and raised the average sales price at option exercise. Compared to the actual scheme offered to program participants, the average time-to-exercise would have declined by 22 months and revenues from sale of those units would have increased by 30%. We further find evidence that anchoring varies with individual and housing market characteristics. Research findings provide real world evidence suggesting the importance of behavioral heuristics to housing decisions and to policy implementation.

## Acknowledgments

The authors thank Yaakov Brosh (CEO), Ronit Gerafi, and Reuven Tunkelrot of Amidar Ltd. for their provision of project data. We are also grateful to Smadar Shatz of Bar Ilan University for the invaluable assistance in generating the dataset and to Yifat Arbel, Shlomo Benartzi, Simon Benninga, Nahum Bigger, Maarten Buis, Denise DiPasquale, Mark Garmaise, David Genesove, Avner Kalay, Ayal Kimhi, Benny Lauterbach, Dan McMillen (the editor), Edgar Olsen, Dan Quan, Bradley Ruffle, Tammie Simmons-Mosley, Avi Wohl, the seminar participants at the Hebrew University of Jerusalem, Bar Ilan University, Tel Aviv University, the 2013 International Meetings of the American Real Estate and Urban Economics Association, the 2014 Israel Real Estate and Urban Economics Symposium, and two anonymous reviewers for their helpful comments. We thank the Israel Science Foundation for the financial support (ISF grant 1170/10).

32 To conserve space, results of exercise are not presented and are available upon request.

33 Equivalent graphs for the case where $POS = 1$ are available upon request.

34 Our finding on the age-anchor interaction is somewhat inconsistent with Mather et al. (2012) who find that age (weakly) positively correlates with loss aversion. Per our outcome on the income-anchor interaction, recall that, as previously reported, the average projected annual income of public housing tenants in our sample is just over 11,306 dollars, which matches the lowest income decile in Israel.

## Appendix A. Price reduction algorithms stratified by sale programs

| Sale program | Dates | Characteristics determining the reduction rate | Formula for determining the marginal contribution of each characteristic to the total reduction rate (in percent) |
|---|---|---|---|
| 1 | February 23, 1999–April 8, 2000 | Number of persons in household and seniority in public housing | Up to $100 \times \frac{3000(\text{NIS}) \times 6 \times 25}{\text{Value(NIS)}}$ |
| | | 100% Disabled confined to a wheelchair living in type A-B-C regions | 10% × Family members with permanent 100% disability |
| | | Single living in type A-B regions | (10,000 NIS + 0.30 × (Value − ((1) + 10,000))) × (100/Value)* |
| | | Couple with or without children living in type A-B regions | (20,000 NIS + 0.30 × (Value − ((1) + 20,000))) × (100/Value)* |
| | | Single living in type C regions | (5000 NIS + 0.25 × (Value − ((1) + 5000))) × (100/Value) * |
| | | Couple with or without children living in type C regions | (10,000 NIS + 0.25 × (Value − ((1) + 10,000))) × (100/Value)* |
| 2 | April 9, 2000–September 14, 2003 | Seniority in the unit tenants living in type A-B-C region | 3.0% × seniority until 1/1/2000<br>+1.5% × 2 for 2001–2002<br>+1.0% for 2003 |
| | | Seniority in the unit (years) 100% disabled confined to a wheelchair living in type A-B-C region | 4.0% × years _of residence until 1/1/2000<br>+1.5% × 2 for 2001–2002<br>+1.0% for 2003 |
| 3 | Sept. 15, 2003–September 14, 2004 | Seniority in the unit (years) tenants living in type A-B regions | 3.0–2.0% × seniority until 1/1/2000<br>+1.5% × 2 for 2001–2002<br>+1.0% × 2 for 2003–2004 |
| | | Seniority in the unit (years) tenants living in type C region | 1.0% × seniority |
| | | Seniority in the unit (years) 100% disabled confined to a wheelchair living in type A-B-C region | 4.0% × seniority until 1/1/2000<br>+1.5% × 2 for 2001–2002<br>+1.0% × 2 for 2003–2004 |
| 4 | January 1, 2005–August 10, 2005 | Single living in type A-B regions | 25% |
| | | Couple without children in type A-B regions | 50% |
| | | Couple with 1 child in type A-B regions | 70% |
| | | Couple with at least 2 children in type A-B regions | 85% |
| | | 100% Disabled confined to a wheelchair in type A-B regions | 85% |
| | | Units located in type C regions | No reduction |

*(1) is equal to 3,000(NIS) × 6 × 25. Also, defining A = 5000; 10,000; 20,000 NIS, and B = 0.25; 0.30, for 100% disabled tenants confined to a wheelchair the formula becomes ((2) + (A + B × (Value − ((2) × Value + A)))) × (100/Value). In calculating B × (Value − ((1) + A)) or B × (Value − ((2) × Value + A)), Value equals the appraised value of the unit if Value ≤ 400, 000 NIS and 400,000 NIS if Value > 400, 000 NIS.

| Sale program | Dates | Characteristics determining the reduction rate | Formula for determining the reduction rate (percent) |
|---|---|---|---|
| 5 | August 11, 2005–December 31, 2006 | Single living in type A-B regions | 25% |
| | | Couple without children in type A-B regions | 50% |
| | | Couple with 1 child in type A-B regions | 70% |
| | | Couple with at least 2 children in type A-B regions | 85% |
| | | Single living in type C regions | 15% |
| | | Couple without children in type C regions | 40% |
| | | Couple with 1 child in type C regions | 70% |
| | | Couple with at least 2 children in type C regions | 85% |
| | | 100% Disabled confined to a wheelchair in type A-B-C regions | 85% |
| 6 | February 11, 2007–August 31, 2008 | Single living in type A-B regions | 25% |
| | | Couple without children in type A-B regions | 46% |
| | | Couple with 1 child in type A-B regions | 69% |
| | | Couple with at least 2 children in type A-B regions | 92% |
| | | Single living in type C regions | 20% |
| | | Couple without children in type C regions | 40% |
| | | Couple with 1 child in type C regions | 60% |
| | | Couple with at least 2 children in type C regions | 80% |
| | | 100% Disabled confined to a wheelchair in type A-B-C regions | 85% |

Notes: The table displays the maximum price reduction rates obtained via the price reduction algorithms and stratified by programs and socio-demographic criteria. The sources of these algorithms are memos of the Ministry of Housing and Construction. Once the unit is purchased, the reduction rate becomes permanent if the purchased unit is not sold within 5 years. Entitlements to be included in the programs are conditioned on minimal duration of residence in the unit for at least between 2 and 12 years depending on the specific program, and full payments of rent fees during that period. 65-year-old tenant is entitled to purchase only if he/she has a couple aged less than 65-year-old, or, alternatively, at least one son or daughter living in Israel. Compared to the reduction rates reported in the table, lower reduction rates were offered to tenants whose rent fees were not subsidized by the government (including setting price reduction rates to zero for those households during program's 3 period). The programs include ceilings of the lowest between 75% and 300,000 NIS (program 1), 90%–95% (program 2 – non-disabled and disabled), 70%–80% (program 3 – for entitled tenants living in units located in type C and type B regions). Value is the unit's value based on appraiser's report. For programs' objectives, children whose age is above 21 years old are neither counted as family members nor as children.

## Appendix B. Reduction Rates by tenant, locational and building characteristics

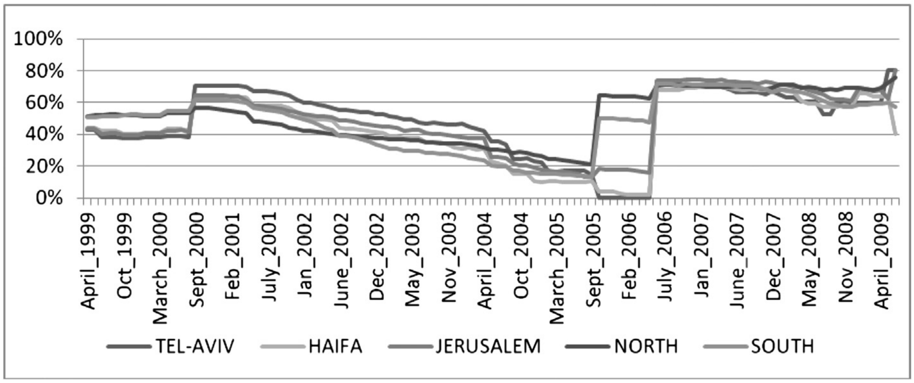


**Fig. B1.** Reduction rates by location. Notes: Tel-Aviv, Haifa and Jerusalem are the three largest cities in Israel.

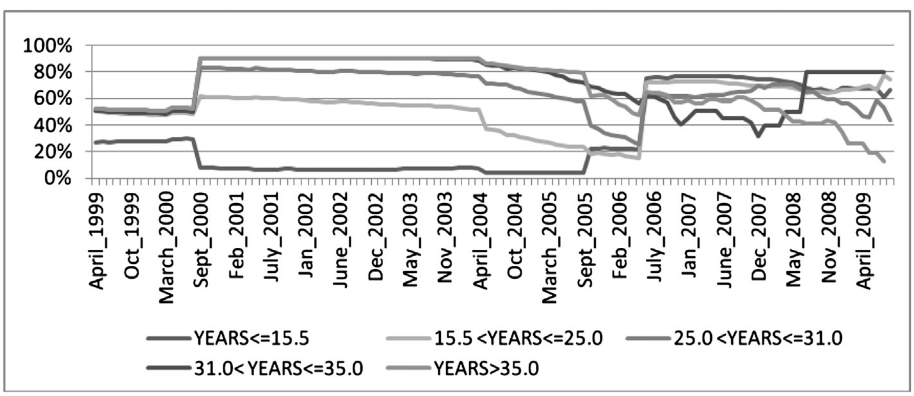


**Fig. B2.** Reduction rate schemes by duration of residence in public housing. Notes: Duration in the public housing project is stratified by sample quintiles:

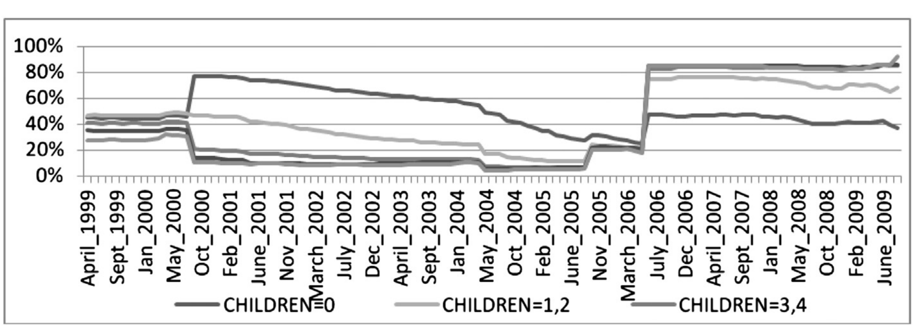


**Fig. B3.** Reduction rates by number of children in household. Notes: Fig. B3 only refers to children under 21 years old.

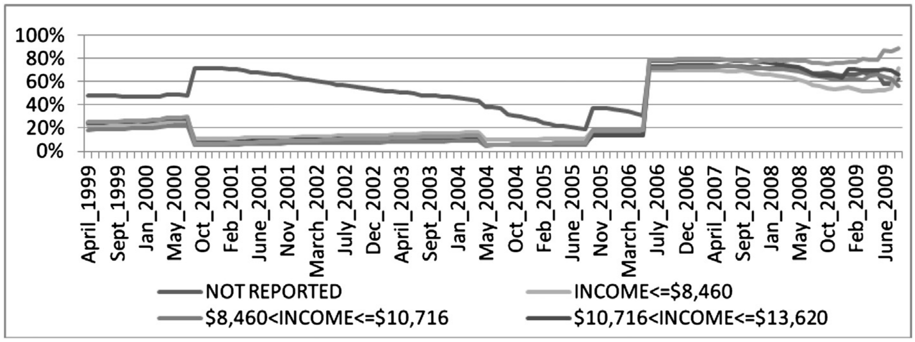


**Fig. B4.** Reduction rates by household income. Notes: Out of 6852 households participating in the estimation, 1002 reported their level of income. Reported levels of income are translated to US$ and stratified by sample quartiles.

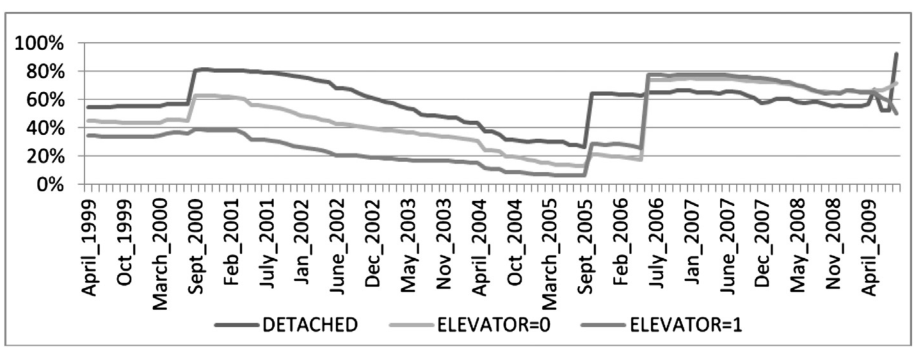


**Fig. B5.** Reduction rates by type of structure. Notes: Structure types include: detached units, condominiums in structures with an elevator, and condominiums in structures without an elevator.

## Appendix C. Tests for unit-roots in reduction rates for all panels

| Fisher-type based on ADF unit-root test | Statistic | p-value |
|---|---|---|
| Inverse chi-squared test | 5520.99 | 1.00 |
| Inverse normal | 53.53 | 1.00 |
| Inverse logit | 49.05 | 1.00 |
| Modified inverse chi-squared | −49.44 | 1.00 |

Notes: The four tests examine the null hypothesis that all 6,853 panels contain unit roots based on Augmented Dickey Fuller tests.

## Appendix D. Auxiliary regressions for generating permanent income

| Matrix | Variables | Eq. (2) | Eq. (3) |
|---|---|---|---|
| $X_1$ | $DURATION_i$ | 9.64*** | −0.03*** |
| | | (3.48) | ($6.27 \times 10^{-4}$) |
| $X_1$ | $DIVORCED_i$ | −3799.00*** | 0.62*** |
| | | (70.20) | (0.02) |
| $X_1$ | $WIDOW_i$ | −3081.00*** | 0.42*** |
| | | (71.78) | (0.02) |
| $X_1$ | $SINGLE\_PARENT_i$ | −1912.00*** | 0.61*** |
| | | (71.27) | (0.02) |
| $X_1$ | $SINGLE_i$ | −5177.00*** | 0.13*** |
| | | (66.60) | (0.02) |
| $X_1$ | $D_i$ | 12.90*** | 0.01*** |
| | | (0.93) | ($2.28 \times 10^{-4}$) |
| $X_1$ | $WHEELCHAIR_i$ | −880.10*** | −0.91*** |
| | | (231.70) | (0.06) |
| $X_1$ | $HEAD\_AGE_i$ | −11.93*** | 0.02*** |
| | | (1.91) | ($5.12 \times 10^{-4}$) |
| $X_1$ | $NORTH_i$ | 230.30** | 0.21*** |
| | | (95.26) | (0.03) |
| $X_1$ | $GUSH\_DAN_i$ | 700.00*** | −0.36*** |
| | | (112.20) | (0.03) |
| $X_1$ | $SOUTH_i$ | 3.96 | 0.25*** |
| | | (94.71) | (0.03) |
| $X_1$ | $JERUSALEM_i$ | 1090.00*** | −0.27*** |
| | | (123.70) | (0.03) |
| $X_1$ | $CENTER_i$ | 617.50*** | −0.05 |
| | | (108.70) | (0.03) |
| $X_1$ | $KRAYOT_i$ | 813.20 | −0.01 |
| | | (698.50) | (0.21) |
| $X_1$ | $SHARON_i$ | 570.70*** | −0.26*** |
| | | (111.80) | (0.03) |
| $X_1$ | $TEL\_AVIV_i$ | 658.10*** | −0.30*** |
| | | (183.20) | (0.05) |
| $X_2$ | $CHILDREN_i$ | – | 0.16*** |
| | | – | ($4.91 \times 10^{-3}$) |
| $X_2$ | $AREA_i$ | – | $-2.53 \times 10^{-4}$*** |
| | | – | ($6.53 \times 10^{-5}$) |
| $X_2$ | $ROOMS_i$ | – | −0.16*** |
| | | – | (0.01) |
| $X_2$ | $FLOOR_i$ | – | 0.04*** |
| | | – | ($4.90 \times 10^{-3}$) |
| $X_2$ | $FLOORS_i$ | – | 0.02*** |
| | | – | ($4.99 \times 10^{-3}$) |
| $X_2$ | $ELEVATOR_i$ | – | 0.02 |
| | | – | (0.03) |
| $X_2$ | $SHELTERS_i$ | – | 0.11*** |
| | | – | (0.01) |
| $X_2$ | $ENTRANCES_i$ | – | 0.02*** |
| | | – | ($3.18 \times 10^{-3}$) |
| $X_2$ | $CONST\_AGE_i$ | – | 0.02*** |
| | | – | ($4.00 \times 10^{-4}$) |
| $X_2$ | $PUBLIC_i$ | – | $-2.22 \times 10^{-3}$*** |
| | | – | ($2.36 \times 10^{-4}$) |
| | Inverse-Mills ratio $\left(\frac{\phi(z_i')}{\Phi(z_i')}\right)$ | 1164.00*** | – |
| | | (135.90) | – |
| | Constant | 11,216.00*** | −0.98*** |
| | | (178.90) | (0.06) |
| | Observations | 35,825 | 58,665 |
| | Chi-square statistics | 8,822*** | 158.72*** |

Notes: The table displays the outcomes of the auxiliary regressions from which the permanent income has been generated for each household in the sample. The dependent variable in Eq. (2), which is estimated via the Maximum Likelihood (ML) procedure, is the annual level of current income. The dependent variable in the selection Eq. (3), estimated as a probit equation using maximum-likelihood procedure, is a selection variable with 2 categories: 1 = tenants who report their level of income (35,825 tenants), and 0 = otherwise. These two latter categories cover the full sample of 58,665 tenants at the beginning of the sample period. Numbers in parentheses are standard errors. Significant values at a 5% (1%) level are marked with two (three) asterisks.

## Appendix E

We test the effect of the interaction of the anchoring variable with *AGE*, *PROJ_INC*, and *PUBLIC*. To undertake the test, we extend the Cox Proportional Hazard model in the following way[35]:

$$\lambda(t) = \lambda_{02}(t)\exp\left[\pi_1 ANCHOR_{i,t} + \pi_2 RED_{i,t} + \theta_{11} D_i \times V_i + CONTROL \cdot \overline{\pi}_3^T + \psi_{2,i,t}\right] \tag{E1}$$

where

$$\pi_1 = \theta_1 NEG_{i,t} + \theta_2 POS_{i,t} + \theta_3 NEG_{i,t} \times V_i + \theta_4 POS_{i,t} \times V_i, \tag{E1.1}$$

$$\begin{aligned}\pi_2 = {} & \theta_5 NEG_{i,t} + \theta_6 POS_{i,t} + \theta_7\left(1-NEG_{i,t}\right)\cdot\left(1-POS_{i,t}\right) + \theta_8 NEG_{i,t} \times V_i \\ & + \theta_9 POS_{i,t} \times V_i + \theta_{10}\left(1-NEG_{i,t}\right)\cdot\left(1-POS_{i,t}\right) \times V_i,\end{aligned} \tag{E1.2}$$

$$\overline{\pi}_3 = (\theta_{12}, \theta_{13}, \ldots, \theta_{16}). \tag{E1.3}$$

$$CONTROL = \left\{BENEFIT_{i,t}, \Delta YIELD\_STD_{i,t}, PROJ(INCOME)_i, MORTGAGE_t, APPRECIATION_{i,t}\right\} \tag{E1.4}$$

$V = \{AGE, PROJ\_INC, PUBLIC\}$ represents the interaction variables and other variable are as described above. We incorporate in Eq. (E1) six types of interaction terms: $ANCHOR_{i,t} \times NEG_{i,t} \times V_i$; $ANCHOR_{i,t} \times POS_{i,t} \times V_i$; $RED_{i,t} \times NEG_{i,t} \times V_i$; $RED_{i,t} \times POS_{i,t} \times V_i$; $RED_{i,t} \times (1\text{-}NEG_{i,t}) \times (1\text{-}POS_{i,t}) \times V_i$; and $D \times V_i$, where $D$ equals 1 in the case where the interaction variable $V_i$ was not specified in the model in Eq. (1) (i.e., $D$ equals 1 when $V_i = \{AGE_i, PUBLIC_i\}$ and 0 when $V_i = \{PROJ\_INC_i\}$). This structure of the model allows $ANCHOR_{i,t}$, and $RED_{i,t}$ to vary with different levels of the specified interaction variable.

Accordingly, we extend the test of anchoring in Eq. (1) by estimating the change (increase or decrease) in the hazard to exercise based on the estimated coefficients and the specified interaction variable. The relevant expressions by which we assess the marginal effect of a 1% increase in the anchor on the hazard to exercise for various level of the interaction variable are $\theta_1 + \theta_3 V_i$ and $\theta_2 + \theta_4 V_i$ for $NEG = 1$ and $POS = 1$, respectively.

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[35] Recall that in addition to Eq. (E1) the model also includes Eqs. (2)–(3), from which *PROJ(INCOME)* is generated.

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