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ARE THE DISABLED LESS LOSS AVERSE? EVIDENCE FROM A NATURAL POLICY EXPERIMENT

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Research findings show that disabled persons often develop physical and psychological mechanisms to compensate for disabilities. Coping mechanisms may not be limited to the psychophysiological domain and may extend to cognitive bias and loss aversion. In this study, we apply unique microdata from a natural policy experiment to assess the role of loss aversion in home purchase among nondisabled and disabled households. Results of survival analysis indicate that the physically disabled are substantially less loss averse in home purchase. Furthermore, loss aversion varies with other population characteristics and attenuates with degree of disability. Findings provide new evidence of diminished cognitive bias and more rational economic decision-making among the physically disabled. (*JEL* D03, C9, R38)

I. INTRODUCTION

A large literature points to differences in cognitive bias among diverse populations. According to Lunn and Lyons (2010), lower-income, less-educated, and older populations are more prone to decision-making that deviates from economic rationality (also see Mather et al. 2012 and Tymula et al. 2013). However, as discussed by Lunn and Lyons (2010), little is known about the decision-making biases of other vulnerable populations, notably the physically disabled, or implications thereof for their economic well-being.

In this study, we examine differences in cognitive bias and behavioral heuristics among nondisabled and physically disabled populations. Specifically, using data from a unique Israeli government natural policy experiment, we assess loss aversion among nondisabled and disabled populations in the decision to purchase a home.

Our empirical tests are motivated by previous findings in physiology and psychology showing that disabled persons often develop physical and mental mechanisms to help compensate for disabilities. According to Bishop (2005), disabled persons utilize such coping mechanisms to minimize gaps caused by their impairments. As further suggested by Devins et al. (1983), Yoshida (1993), Livneh and Antonak (1997), and Bishop and Feist-Price (2002), such strategies and mechanisms allow disabled persons increased control over their health and environment. Specifically, Nirje (1972), Sands and Wehmeyer (1996), and Wehmeyer (1998) suggest that disabled populations seek compensatory mechanisms to enhance autonomy, efficacy, self-reliance, and self-management.

Among noteworthy examples, Cattaneo and Vecchi (2011) summarize a long series of studies indicating the development of compensatory mechanisms among visually impaired persons. Results of those analyses indicate enhanced nonvisual, perceptual, sensorial, and cortical-level abilities among the visually disabled (e.g., Amedi et al. 2003; Crawford et al. 2008; Hamilton, Pascual-Leone, and Schlaug 2004; Hull and Mason 1995; Muchnick et al. 1991; Röder, Rosler, and Neville 2001; Niemeyer and Starlinger 1981).

In other recent work, Keysar, Hayakawa, and An (2012) provide evidence of compensatory

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cognitive mechanisms among persons with language impairments. Results of experimental analysis indicate diminished decision biases and reduced loss aversion among non-native language speakers. The authors hypothesize that use of a foreign language reduces the opportunity for spontaneous response and results in a more consciously measured and considered mode of thinking.[1]

As with visually or language-impaired persons, the compensatory mechanisms acquired by physically disabled persons may extend beyond the psychophysiological domain to include cognitive adjustments. Indeed, as discussed by Stanovich and West (2000), lower levels of cognitive bias could compensate for physical disability and provide for improved coping prospects.

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 algorithms utilized by the government to determine the magnitudes of the price reductions varied over time; furthermore, the price reductions were not forecastable among targeted program participants. Tenants had the opportunity to either accept or decline government sales offers extended at each successive program iteration. Our research employs survival analysis to specify and empirically test whether physically nondisabled and disabled tenants exhibited different degrees of loss aversion behavior in their home purchase decisions.[2]

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" (p. 279). In experimental work, Tversky and Kahneman (1992) find that, under even odds for winning and losing, the gain should be at least twice as large as the loss for a prospect to be acceptable, whereas Putler (1992) finds, for example, that consumers are two and a half times more responsive to price increases that are in excess of the reference price than they are to comparable price declines.[3] Results from this literature suggest that the reference price (to which losses and gains are compared) may include, for example, the previous price of the product, prices of other products, some functional form of mean past prices, most common past price, peak past price, and future expected price (e.g., Briesch et al. 1997; Eichenbaum, Jaimovich, and Rebelo 2011; Jacobson and Obermiller 1990; Krishnamurthi, Mazumdar, and Raj 1992; Niedrich, Sharma, and Wedell 2001; Rajendran and Tellis 1994; Winer 1986).[4]

Specifically, we estimate the asymmetric response of nondisabled and disabled households to losses and gains associated with deviations in home price reduction rates from a reference reduction rate. In our context, a household experiences a loss whenever the current rate of price reduction is less than the reference reduction rate. In contrast, the household experiences a gain if the proposed rate of reduction in price exceeds the reference rate.[5] In that vein, a greater absolute effect of a loss (compared to a gain) in the hazard to purchase is consistent with loss-averse behavior. In other words, loss aversion implies that the decrease in the hazard to purchase following a loss is greater in absolute

1. Recent experimental work similarly suggests lower levels of loss aversion among persons suffering from mental illness (e.g., Tremeau et al. 2008).

2. Arbel, Ben-Shahar, and Gabriel (2014) test for the prevalence of the anchoring heuristic in timing of home purchase among public housing residents. The current study extends the methodology used in the study by Arbel, Ben-Shahar, and Gabriel (2014) to assess the loss aversion behavior of disabled persons.

3. Further evidence on the asymmetric response to gains and losses is found, for example, in the study by Kalwani and Yim (1992), Mayhew and Winer (1992), Hardie, Johnson, and Fader (1993), Kalyanaram and Little (1994), and Pedace and Smith (2012). For neurophysiological evidence on the asymmetry in the reaction to gains and losses see, for example, Weber et al. (2007), Votinov et al. (2010), De Martino, Camerer, and Adolphs (2010), and Tom et al. (2007). Also see the review article by Rick (2011).

4. In contrast to the literature that examines reference prices, Koszegi and Rabin (2006) examine a reference point reflecting probabilistic beliefs about possible outcomes. Under this approach, one's derived utility from a purchase depends on both the price one is expected to pay and the *probability* to purchase the good. In contrast, our setting allows us to empirically assess the robustness of purchase behavior to differing expectations regarding the reference price, but not to the probabilities with which one is expected to buy. Further, unlike Koszegi and Rabin (2006), we hypothesize that the formation of expectations associated with the reference point is exogenous and adaptive rather than endogenous and based on rational expectations (in this context see also Koszegi and Rabin 2007, 2009).

5. Also, from a rational economic perspective, the lower loss aversion of disabled persons may be attributed to their potentially greater costs of search in moving to a different housing unit. Particularly, it may be the case that when the reduction rate over the market price declines, the nondisabled tenant will defer the home purchase whereas the disabled tenant might still exercise the purchase option as his alternative purchase would, *ceteris paribus*, associate with a greater search cost due to special housing needs related to physical disability.

value than the increase in the hazard to purchase following a gain.

Our reference reduction rate takes the form of a simple average of all prior price reduction rates offered to the household. Furthermore, we test the robustness of results to other reference rates.[6] The severity of the household physical disability is indicated by a disability index (on a scale of 0% for nondisabled to 100% for severe cases of physical disability) as determined by a medical committee of the National Insurance Institute of Israel. We also examine the sensitivity of loss aversion behavior among nondisabled and disabled households to individual demographic characteristics and to different definitions of the reference rate.

Research findings provide evidence of substantial loss aversion in home purchase among both nondisabled and disabled households. However, disabled households are significantly *less* loss averse than are the nondisabled. Specifically, results show that while nondisabled households are 4.55 times more responsive to *declines* in price reduction rates than they are to comparable *increases* in those rates, the same loss-gain ratio for fully disabled households is 2.92 (the difference between these estimates is significant at the 1% level). Furthermore, the estimated reduction in loss aversion among disabled populations is robust to differences in reference rates and sample variations. Moreover, as in prior studies, we find that loss aversion is sensitive to demographic characteristics such as age of household head and marital status.[7] Empirical findings provide new evidence of diminished cognitive bias and more rational economic decision-making among the physically disabled.

Results accordingly suggest economy-wide benefits of enhanced outreach and employment of disabled persons. Indeed, while the employment-to-population ratio among nondisabled persons in the United States stood at about 65% in 2014 (Bureau of Labor Statistics 2015), the equivalent figure for the disabled population was only 17%. Our study identifies a potential economic benefit of employing disabled persons: namely, that, compared with nondisabled persons, disabled employees exhibit attenuated cognitive bias, which may be translated to more rational decision making to the benefit of employers.

The plan of the article is as follows: Section II describes the sales programs and Section III presents the data and controls. Section IV presents the empirical model and Section V provides evidence of asymmetric response to losses and gains in the price reduction rates across nondisabled and disabled populations. Section VI presents a series of robustness tests, whereas Section VII examines the sensitivity of the estimated loss-gain ratio to demographic characteristics of nondisabled and disabled households. Finally, Section VIII provides summary and concluding remarks.

II. THE SALES PROGRAMS

We apply unique microdata from a recent natural policy experiment to empirically explore loss aversion among nondisabled and physically disabled households. The data span the 1999–2008 period and include six consecutive programs, which provide incentives to residents of public housing to purchase their dwelling unit.[8] The home sales programs can be described as call (real) options that allowed tenants to purchase their public rental units within a given timeframe and at a specified exercise price. The exercise prices were set as a function of the market price net of programmatic price reductions computed as percentage discounts from the market value of the asset. Each iteration of the program provides an opportunity to assess tenant behavioral response to a specified incentive structure. The panel nature of the data allows us to examine tenant response to successive program incentives, controlling for household socioeconomic and demographic as well as market characteristics.

Table A1 shows the origination and termination dates of each sales program and the detailed criteria by sales program for tenant-offered price reductions. As is evident in the table, the duration of the sales programs varied substantially. For example, the second sales program was in effect for 41 months, whereas the fourth program

6. While the simple average of one's past price reduction rates appeared most significant as a reference in our outcomes, our results were qualitatively robust to other reference rates including one's first and previous maximum reduction rate (see Sections V and VI).

7. Specifically, degree of loss aversion among both disabled and non-disabled households declines with unmarried status and age. This result stands in contrast to the experimental finding of Mather et al. (2012) which showed that older adults were more loss averse than younger adults. Recent empirical literature further indicates that the degree of loss aversion varies with other individual characteristics as well as market conditions (see, among others, Genesove and Mayer 2001; Li et al. 2012; List 2003, 2004, 2011; Vieider 2009; Zhang and Fishbach 2005).

8. Note that the sixth and final sales program concluded in September 2008.

lasted just 7 months. Furthermore, the algorithm for determining tenant price reductions changed considerably from one program to the next. In the first sales 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 household residence in a priority region together with family status (single persons vs. 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. While current price reduction criteria were available to the public, the timing of successive programs as well as the choice of weights assigned to future criteria were erratic and unpredictable (see further discussion below).

As shown in Appendix B, the price reduction rates varied considerably across stratifications of the sample by sociodemographic, disability, locational, and dwelling characteristics (including location, duration in the public housing project, number of children under 21 years old, income, and type of structure). Furthermore, 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 reduction series in all panels are nonstationary. Hence, we could not reject the null hypothesis that the offer price reduction time-series follow a random walk. Those findings suggest that tenants could not have forecasted the successive price reduction schemes so as to strategically exercise the purchase option.

III. SAMPLE AND CONTROLS

Data for the analysis comprise all public housing tenants residing in Amidar Ltd. housing units. Amidar managed approximately two-thirds of the total public housing stock in Israel in 1999 and was the largest public housing corporation in Israel during the period of analysis.[9] The raw sample includes 84.11% of the dwelling units managed by Amidar (total of 58,849 units). Given the focus of the study, we adjust the sample to exclude units that were inaccessible to the physically disabled. Accordingly, the sample of disabled households includes detached and first-floor condominium units as well as units above the first floor in structures with an elevator. Furthermore, as shown below, statistical outcomes are robust to variations in sample selection. As the decision not to purchase the dwelling may arise due to household financial constraints rather than because of loss aversion or other concerns, we limit the analysis to those households exercising the purchase option (and address potential sample selection issues in Section IV). Accordingly, the statistical analysis focuses on the effect of loss aversion on timing of home purchase option exercise among nondisabled and disabled households. The final sample thus consists of an unbalanced panel of 6,853 households including 6,543 nondisabled buyers and 310 disabled buyers.[10]

We assess the response of tenants to varying price reduction rates over a period of up to 114 months (i.e., the period of the six sales programs, March 1999–August 2008). The monthly data allow for variability in tenant reduction rates during each sales program as could arise due to changing household sociodemographic characteristics (such as the birth of a child).

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 to 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.

Table 1 provides summary statistics on the cross-section of nondisabled and disabled home purchasers at the date of purchase.[11] Table 2 presents summary statistics of nondisabled and disabled purchasers for the sample panel across all time periods (excluding the date of purchase). As indicated in Table 1, the average appraised

9. Eligibility criteria to public housing are determined by the Ministry of Construction. Two necessary (not sufficient) conditions to be eligible for public housing include no homeownership of any sort and income level (from all sources) not exceeding the minimum wage level (see Ministry of Construction and Housing 2007).

10. Purchasers who entered the sample after the beginning of the sample period and cases of missing information regarding rent payments have been further omitted from the sample.

11. All variables measured in NIS (New Israeli Shekels) are converted to U.S. dollars using an exchange rate of 1 NIS = $0.25.

value (before reduction) of the purchased housing units (*UNIT_VALUE*) at the date of purchase was \$89,221 for nondisabled and \$95,581 for disabled buyers.[12] Table 1 further indicates that the average rate of price reduction of purchased units from appraised value at the date of purchase ($RED_{i,t}$) was 78% and was roughly equivalent across nondisabled and disabled groups. As is evident, public housing tenants exercised the purchase option at deeply discounted values.

Tables 1 and 2 further provide information on $REF_{i,t}$, the simple average of all prior $(t-1)$ home price reduction rates offered to tenant i at time t. Following Kahneman and Tversky (1979), we further compute $|RED_{i,t} - REF_{i,t}| \times NEG_{i,t}$, where $NEG_{i,t}$ equals 1 in the case that $RED_{i,t} - REF_{i,t}$ is negative and 0 otherwise and $|RED_{i,t} - REF_{i,t}| \times POS_{i,t}$, where $POS_{i,t}$ equals 1 in the case that $RED_{i,t} - REF_{i,t}$ is positive and 0 otherwise. Based on the definition of loss aversion provided by Tversky and Kahneman, the terms $|RED_{i,t} - REF_{i,t}| \times NEG_{i,t}$ and $|RED_{i,t} - REF_{i,t}| \times POS_{i,t}$ measure household i's loss and gain, respectively, in comparing the current reduction rate to the reference reduction rate.

As shown in Table 2, for the entirety of the panel, the average of $|RED_{i,t} - REF_{i,t}| \times NEG_{i,t}$ (when $NEG_{i,t} = 1$) and $|RED_{i,t} - REF_{1,i,t}| \times POS_{i,t}$ (when $POS_{i,t} = 1$) is 10.67% and 21.06%, respectively, for the nondisabled group, and 13.82% and 29.07%, respectively, for the disabled group. At the date of purchase (Table 1), however, the respective average of $|RED_i - REF_i| \times NEG_i$ and $|RED_i - REF_i| \times POS_i$ is 5.93% and 25.72% for the nondisabled population, and 7.68% and 40.26% for the disabled population. It follows that the average of $|RED_{i,t} - REF_{i,t}|$ on the exercise date is less than (exceeds) the on-sample panel average for cases where $RED_{i,t} < REF_{i,t}$ ($RED_{i,t} > REF_{i,t}$). These findings provide a preliminary indication of loss aversion behavior in purchase option exercise. As a further indication of loss aversion behavior, note (from Tables 1 and 2) that while the expression $RED_{i,t} - REF_{i,t}$ is negative (i.e. $NEG_{i,t} = 1$) on average in 28% and 29% of the periods for the nondisabled and disabled groups, respectively, over the entire on-sample panel, those figures drop to 5% and 4%, respectively, at the date of purchase.

The summary statistics displayed in Tables 1 and 2 further include a large number of household socioeconomic, dwelling, and local housing market characteristics. Among housing market characteristics, note that tenant annual average net rent is only about \$815 and \$618, respectively, among the nondisabled and disabled population, reflecting the very low rental payments associated with public housing. The low levels of rent suggest damped incentives for residents of public housing to exercise the purchase option. Note further that our volatility index of housing risk, based on indices of average transaction prices for the nine statistical regions in Israel (Israel Central Bureau of Statistics) and measured by the standard deviation of annual yield on condominium prices ($STD_{i,t}$), averaged 3.79% for nondisabled and 4.47% for disabled. Finally, the average annual dwelling appreciation rate ($APPRECIATION_{i,t}$) is 2.73% for nondisabled and 1.57% for disabled tenants.

Table 1 further includes summary information on sample household sociodemographic characteristics. Those measures include $MARRIED_i$, $DIVORCED_i$, $WIDOW_i$, and $SINGLE\ PARENT_i$; whether the household has children (under 21 years of age ($WITH\_CHILDREN_i$); total number of children in the household ($CHILDREN_i$); age of household head ($HEAD\_AGE_i$); and annual current income ($INCOME_i$). As shown in the table, the average current annual income of sampled nondisabled and disabled households is roughly the same at \$11,268 and \$11,578, respectively.[13] Interestingly, the marital rate among sampled nondisabled households (47%) is far below that of disabled households (62%).

12. Comparably, according to the Israeli Central Bureau of Statistics, the (non-quality adjusted) mean value of a transacted housing unit in the private market over this period was \$171,450 with a standard deviation of \$12,150. Also, in the unbalanced panel, the *UNIT_VALUE* was 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 nine statistical regions published by the Israel Central Bureau of Statistics.

13. Unlike the United States, low-income households in Israel are generally exempted from filing tax returns. In November 2005, all tenants were required to file an updated report in order to preserve their entitlement to receive rent subsidy; however, only limited sanctions were put into place by the Ministry of Housing and Construction for not filing such a report on part of public housing tenants. Thus, income is available for only 864 of the 6,543 nondisabled tenants and 138 of the 310 disabled 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. Also, the average annual net income per household in Israel over the examined period is about \$30,000. The \$11,578 annual income figure of the nondisabled group matches the lowest income decile in Israel. Furthermore, note that, on average, the net-of-reduction housing purchase price is equivalent to about 21 months of earnings.

TABLE 1

Summary Statistics Stratified by Disability Index—Cross Section of Buyers at the Date of Purchase

Variable	Definition	Nondisabled	Disabled
Housing value and reduction characteristics			
$UNIT\_VALUE_i$	Value of housing units translated to dollars	89,221.14	95,581.00
$RED_{i,t}$	Current reduction rates in percentage points	78.07	78.31
AVG_RED_t	The average current reduction rate across all households at time t in percentage points	49.48	53.92
$RENT\_NET_i$	Net annual rent payment translated to U.S. dollars	815.35	618.16
$REF_{i,t}$	Accumulated average of all previous (up to $t-1$) price reduction rate	53.84	39.38
$RED_i - REF_i$	Difference between RED_i and REF_i	23.93	38.28
NEG_i	1—reduction rate drop; 0—otherwise	0.05	0.04
POS_i	1—reduction rate rise; 0—otherwise	0.94	0.96
$REF_i \times NEG_i$ ($NEG_i = 1$)	Accumulated average of all previous (up to $t-1$) price reduction rate only in the case of a drop	57.50	53.26
$REF_i \times POS_i$ ($POS_i = 1$)	Accumulated average of all previous (up to $t-1$) price reduction rate only in the case of a rise	53.84	39.38
$\lvert RED_i - REF_i\rvert \times NEG_i$ ($NEG_i = 1$)	Negative difference between the current price reduction rate and accumulated average of all previous reduction rates in absolute values	5.93	7.68
$\lvert RED_i - REF_i\rvert \times POS_i$ ($POS_i = 1$)	Positive difference between the current price reduction rate and accumulated average of all previous reduction rates in absolute values	25.72	40.26
Household characteristics			
$INCOME_i$	Net current annual income translated to U.S. dollars	11,267.94	11,577.85
D_i	The highest disability index of the adult household members on a scale between 0% (households whose head of the household and spouse are both nondisabled) to 100% (households with at least one adult member who is totally dependent disabled)	0.00	77.67
$WHEELCHAIR_i$	1—at least one adult household member is confined to a wheelchair; 0—otherwise	0.00	0.30
$DURATION_i$	Duration of residence in public housing asset measured in years	23.03	17.51
$WITH\_CHILDREN_i$	1—households with at least one child under 21 years of age; 0—otherwise	0.31	0.50
$CHILDREN_i$	Number of children in households with at least one child	2.54	2.63
$MARRIED_i$	1—married; 0—otherwise	0.47	0.62
$DIVORCED_i$	1—divorced; 0—otherwise	0.06	0.06
$WIDOW_i$	1—widow; 0—otherwise	0.16	0.10
$SINGLE\_PARENT_i$	1—single parent; 0—otherwise	0.15	0.12
$SINGLE_i$	1—single; 0—otherwise	0.15	0.10
$HEAD\_AGE_i$	Age of the head of the households	62.27	58.61
Housing and regional characteristics			
$UNIT\_VALUE_i$	Value of housing units translated to dollars	89,221.14	95,581.00
$STRUCT\_AGE_i$	Age of structure in years until 2008	31.98	30.67
$CONDOMINIUM_i$	1—if there is no elevator in the structure and the unit is located in the first floor; 0—otherwise	0.25	0.61
$ELEVATOR_i$	1—if there is an elevator in the structure; 0—otherwise	0.10	0.29
$DETACHED$	1—if the unit is detached; 0—otherwise	0.09	0.10
$FLOOR_i$	The floor in which the apartment is located if there is an elevator in the structure	3.41	3.17
$ROOMS_i$	Number of rooms	3.21	3.15
$AREA_i$	The area of the housing units translated to square feet	796.68	815.43
$ENTRANCES_i$	Number of entrances to the structure	2.33	2.13
$SHELTERS$	Number of shelters in a structure for a shield during a war	0.33	0.32
$STRUCT\_PER$	Percentage of structure owned by the government	79.94	61.88
$HAIFA_i$	1—if the location is in Haifa; 0—otherwise	0.06	0.03
$NORTH_i$	1—if the location is in the North; 0—otherwise	0.12	0.13
$GUSH\_DAN_i$	1—if the location is in Gush Dan; 0—otherwise	0.19	0.27
$SOUTH_i$	1—if the location is in the South; 0—otherwise	0.18	0.15
$JERUSALEM_i$	1—if the location is in Jerusalem; 0—otherwise	0.12	0.09
$CENTER_i$	1—if the location is in the center; 0—otherwise	0.16	0.15
$KRAYOT_i$	1—if the location is in Krayot; 0—otherwise	0.01	0.00
$SHARON_i$	1—if the location is in Sharon; 0—otherwise	0.14	0.16
TEL_AVIV_i	1—if the location is in Tel-Aviv; 0—otherwise	0.02	0.01

TABLE 2
Summary Statistics Stratified by Disability Index—On-Sample Panel (All Periods Excluding the Date of Purchase)

Variable	Definition	Nondisabled	Disabled
$UNIT\_VALUE_{i,t}$	Deflated value of housing units translated to dollars	86,546.13	90,921.95
$RED_{i,t}$	Current price reduction rates in percentage points	45.98	34.66
$RED\_DOLLAR_{i,t}$	Current price reduction rates in percentage points	39,574.9	31,188.7
$RENT\_NET_{i,t}$	Net annual rent payment translated to U.S. dollars	734.35	526.37
$MORTGAGE_t$	Long-term annual mortgage rate in percentage points	6.08	5.83
$STD_{i,t}$	Standard deviation of annual return of housing units in percentage points	3.79	4.47
$APPRECIATION_{i,t}$	Annual appreciation of housing values in percentage points	2.73	1.57
$REF_{i,t}$	Accumulated average of all previous (up to $t-1$) price reduction rate	37.96	26.91
$RED_{i,t} - REF_{i,t}$	Difference between $RED_{i,t}$ and $REF_{1,i,t}$	8.02	7.75
$NEG_{i,t}$	1—reduction rate drop; 0—otherwise	0.28	0.29
$POS_{i,t}$	1—reduction rate rise; 0—otherwise	0.52	0.38
$REF_{i,t} \times NEG_{i,t}$ ($NEG_{i,t} = 1$)	Accumulated average of all previous (up to $t-1$) price reduction rates in the case of a drop	35.11	30.57
$REF_{i,t} \times POS_{i,t}$ ($POS_{i,t} = 1$)	Accumulated average of all previous (up to $t-1$) price reduction rates in the case of a rise	46.71	41.29
$\lvert RED_{i,t} - REF_{i,t}\rvert \times NEG_{i,t}$ ($NEG_{i,t} = 1$)	Negative difference between the current price reduction rate and accumulated average of all previous reduction rates in absolute values	10.67	13.82
$\lvert RED_{i,t} - REF_{i,t}\rvert \times POS_{i,t}$ ($POS_{i,t} = 1$)	Positive difference between the current price reduction rate and accumulated average of all previous reduction rates in absolute values	21.06	29.07
Total number of periods		290,869	23,971
Number of periods of where $RED_{i,t} - REF_{i,t} < 0$ ($NEG_{i,t} = 1$)		81,509	6,901
Number of periods of where $RED_{i,t} - REF_{i,t} > 0$ ($POS_{i,t} = 1$)		152,047	9,668

Similarly, compared with 31% of nondisabled households, 50% of disabled households have at least 1 child (under 21 years of age). Finally, the average age of nondisabled and disabled household heads is 62 and 58 years, respectively.[14]

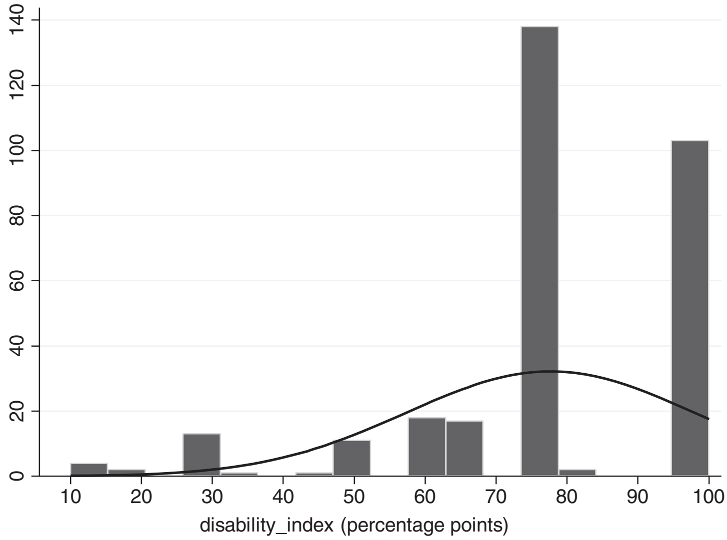
The variable D_i denotes the degree of disability, measured by a disability index, experienced by household i. The disability index ranges from 0% for nondisabled to 100% for severe disability and is determined by formal statutory instructions of a medical committee of the National Insurance Institute of Israel. As shown in Table 1, the sampled disabled population has an average disability index score of just over 77%. Furthermore, Figure 1 displays the distribution of the disability index among disabled public housing tenants in the sample. As is evident, 75% and 100% disability scores are the first and second most frequent levels of disability, respectively. Note as well that 94 of the 310 households in the disability group include those where at least one adult member is confined to a wheelchair ($WHEELCHAIR_i$).

Table 1 further includes structural and locational indicators of purchased units. As indicated in the table, the average size and age of purchased units varies little among nondisabled and disabled households. It is noteworthy, however, that compared with only 19% for nondisabled households, 27% of units purchased by disabled households are located in the Tel Aviv metropolitan area (GUSH DAN).

Building characteristics further include a dummy variable that equals 1 if there is an elevator in the building ($ELEVATOR_i$), a dummy variable that equals 1 for a detached unit ($DETACHED_i$), where the base category is a condominium structure without an elevator, and the floor on which the unit is located for condominiums ($FLOOR_i$). These allow us to restrict

14. Note that while we control for demographic characteristics in our empirical model, our nondisabled control group is not representative of the general population. In particular, among the general population in Israel, about 56% are married, about 92% have at least one child aged 17 or under, and average age is about 43 (see Israel Central Bureau of Statistics 2014). A number of factors may have contributed to the relatively older average age (and lower number of children) of household heads in our sample. Firstly, all 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 rental prices of public housing incentivize tenants to stay in their units. The combination of these factors may limit opportunities for younger households with children to enter the public housing system.

FIGURE 1
Distribution of Disability Index among Disabled Public Housing Tenants



Notes: The histogram refers only to disabled tenants who live in either: the first floor of condominiums without elevator, any floor in condominiums with elevator; or detached units. Disabled tenants who live in condominium apartments without elevators above the first floor were excluded from the sample. Households who entered the public-housing project after $t=0$ were also excluded. The disabled index is measured in percentage points and reflects the highest index among the adult members of the household (in the case that more than one subject per household is disabled). The exact distribution is given in the following table.

Disability Index	**Freq.**	**Percent**	**Cum.**
10	4	1.29	1.29
19	1	0.32	1.61
20	1	0.32	1.94
29	8	2.58	4.52
30	5	1.61	6.13
36	1	0.32	6.45
45	1	0.32	6.77
49	7	2.26	9.03
50	4	1.29	10.32
60	17	5.48	15.81
62	1	0.32	16.13
64	1	0.32	16.45
65	16	5.16	21.61
74	3	0.97	22.58
75	135	43.55	66.13
80	2	0.65	66.77
100	103	33.23	100
Total	310	100	

our data to include only disabled households who reside in dwelling units with direct physical access (i.e., detached units, first-floor condominium units, and nonfirst-floor condominium units with an elevator). Of the dwellings purchased by nondisabled (disabled) households, 9% (10%) are detached units, 25% (61%) are first-floor condominium units without an elevator, and 10% (29%) are condominium units with an elevator (56% of the purchases by the nondisabled group include units above the first floor in condominiums without an elevator).

IV. TESTING FOR LOSS AVERSION AMONG NONDISABLED AND DISABLED GROUPS

We test for systematic variation in loss aversion in the timing of home purchase among nondisabled and disabled populations. To do so, we assess the asymmetric response of nondisabled and disabled tenants to losses and gains associated with changes in dwelling sales price reduction rates relative to a reference reduction rate.

The empirical model consists of the following structural equations:

$$(1)\quad h(t) = h_{00}(t)\, exp[\beta_0 + \beta_1 REF_{i,t} \times NEG_{i,t} + \beta_2 REF_{i,t} \times POS_{i,t} + \beta_3 REF_{i,t} \times \left(1 - NEG_{i,t}\right) \times \left(1 - POS_{i,t}\right) + \beta_4 \left|RED_{i,t} - REF_{i,t}\right| \times NEG_{i,t} + \beta_5 \left|RED_{i,t} - REF_{i,t}\right| \times POS_{i,t} + CONTROL \times \overline{\beta}_6^T + \psi_{0,i,t}],$$

$$(2)\quad z_i^* = X_1\gamma_1 + X_2\gamma_2 + u_{1,i},$$

$$(3)\quad INCOME_i = X_1\gamma_3 + \frac{\phi\left(z_i^*\right)}{\Phi\left(z_i^*\right)} + u_{2,i},$$

where

$$(1.0)\quad \beta_0 = \alpha_6 \times D_i,$$

$$(1.1)\quad \beta_1 = \alpha_1 + \alpha_7 \times D_i,$$

$$(1.2)\quad \beta_2 = \alpha_2 + \alpha_8 \times D_i,$$

$$(1.3)\quad \beta_3 = \alpha_3 + \alpha_9 \times D_i,$$

$$(1.4)\quad \beta_4 = \alpha_4 + \alpha_{10} \times D_i,$$

$$(1.5)\quad \beta_5 = \alpha_5 + \alpha_{11} \times D_i,$$

$$(1.6)\quad \overline{\beta}_6 = \left(\alpha_{12}, \alpha_{13}, \dots, \alpha_{21}\right).$$

In the above system of equations, t and i stand for time and tenant indices, respectively; $h(t)$ denotes the hazard function, which captures the exercise rate of the purchase option; and $h_{00}(t)$ 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 Equation (1) include the reference price reduction rate, $REF_{i,t}$, which is equal to the average of all previous $t-1$ program reduction rates in the price of the dwelling (measured in percentage points—as all price reductions where offered to tenants in percentage points of the fair market value) offered to tenant i at time t; $RED_{i,t} - REF_{i,t}$ denotes the difference between i's current reduction rate and the reference reduction rate; $NEG_{i,t}$ and $POS_{i,t}$ and are dummy variables that equal 1 if $RED_{i,t} - REF_{i,t}$ is negative or positive, respectively, and 0 otherwise.[15] *CONTROL* comprises a matrix of control variables that includes: AVG_RED_t, the current average reduction rate across all i at each t; $RENT\_NET_{i,t}$, the net rent paid by the tenant; ΔSTD_t, the first difference in the volatility of house price returns; $PROJ(INCOME)_i$, the level of permanent income as projected from Equation (3) (see description below); $\Delta MORTGAGE_t$, the first difference (between periods t and $t-1$) in the periodic mortgage rate; $APPRECIATION_t$, the annual appreciation in the value of housing units; $ELEVATOR_i$, a dummy variable that equals 1 if the dwelling unit has an elevator and 0 otherwise; $DETACHED_i$, a dummy variable that equals 1 for a detached unit and 0 otherwise (the base category is condominium structure without an elevator); $STRUCT\_AGE_i$, the age of the structure in years; and $ROOMS_i$, the unit's number of rooms.[16] Also, $\alpha_1, \dots, \alpha_{21}$ are 21 estimated coefficients associated with Equation (1), $\overline{\beta}_6$ is the transpose of the column vector $\overline{\beta}_6^T$, where T is a transpose operator, and $\psi_{0,i,t}$ is the random disturbance term.[17] In an effort to limit the possibility that the decision not to purchase the dwelling unit arises due to household financial constraints rather than loss aversion considerations, we estimate Equation (1) only for the 6,853 households (including both nondisabled and disabled households) who exercised the purchase option at some point during the 114-month observation period.

Note in Equation (1) that we interact our focus explanatory variables, $REF_{i,t}$, and $RED_{i,t} - REF_{i,t}$, with *Sign*, where $Sign = \{NEG_{i,t}, POS_{i,t}, (1 - NEG_{i,t})(1 - POS_{i,t})\}$, in order to examine asymmetric responses to losses and gains associated with changes in $RED_{i,t}$ compared to $REF_{i,t}$ (i.e., the degree of loss aversion).

15. The expression $(1 - NEG_{i,t})(1 - POS_{i,t})$ in Equation (1) thus acts as a dummy that equals 1 when $RED_{i,t} - REF_{i,t} = 0$, and 0 otherwise.

16. While we control for current income, we unfortunately do not observe additional related controls such as (changes in) wealth and employment status. The omission of these controls may affect the empirical findings.

17. Originally, we calculated STD_t as the 3-year standard deviation of monthly price returns on the housing price index. For this time-varying and nonstationary series the unit root hypothesis is not rejected ($p = 66.71\%$). The unit root hypothesis similarly is not rejected for $MORTGAGE_t$ ($p = 34.34\%$). We accordingly specify these non-stationary controls in difference terms. Other variables in the model are found to be stationary. Also, the Israel Central Bureau of Statistics provides a housing price index for the each of the nine regions that comprise the state of Israel. The variable *APPRECIATION* thus represents the periodic rate of housing price appreciation in the region where a given housing unit in our sample is located.

Also, as the variable D_i in Equations (1.0)–(1.5) represents the disability index (on a scale of 0%–100%), the estimation of Equation (1) after substituting these equations allows us to test for different degrees of loss aversion among nondisabled and disabled populations. Specifically, $REF_{i,t} \times Sign$ and $(RED_{i,t} - REF_{i,t}) \times Sign$ are interacted with the disability index, D_i. Hence, for example, in the case where $RED_{i,t} - REF_{i,t} < 0$, α_4 and $\alpha_4 + \alpha_{10} D_i$ in Equation (1) reflect the percent change in the home purchase hazard rate resulting from a 1% increase in $RED_{i,t} - REF_{i,t}$ for nondisabled and disabled tenants, respectively. Similarly, when $RED_{i,t} - REF_{i,t} > 0$ then α_5 and $\alpha_5 + \alpha_{11} D_i$ reflect the percent change in the survival rate resulting from a 1% increase in $|RED_{i,t} - REF_{i,t}|$ for nondisabled and disabled tenants, respectively.[18]

Equations (2) and (3) reflect two auxiliary regressions. The sample for Equation (2) includes the entire population of purchasers and nonpurchasers—a total of 58,665 observations (of which 47,588 are nondisabled and 11,077 are disabled tenants), where the dependent variable, z_i^*, is a binary variable that receives a value of 1 in the case that the household filed an income tax report during the sample period and 0 otherwise (see footnote 13). On the right-hand side of Equation (2), the matrices X_1 and X_2 include vectors of households' sociodemographic, locational, and dwelling structure characteristics, respectively. The matrix X_1 includes: $DURATION_i$ (duration of residence in the public housing asset measured in years); $CHILDREN_i$ (number of children); $DIVORCED_i$ (divorced = 1 and 0 otherwise); $WIDOW_i$ (widow = 1 and 0 otherwise); $SINGLE\_PARENT_i$ (single parent = 1 and 0 otherwise); $SINGLE_i$ (single = 1 and 0 = otherwise); D_i (the disability index on a scale of 0–100); $WHEELCHAIR_i$ (a member of the household is confined to a wheelchair = 1 and 0 otherwise); $HEAD\_AGE_i$ (head-of-household age in years at purchase date or at the end of the sample period if did not purchase); and $NORTH_i$, $GUSH\_DAN_i$, $SOUTH_i$, $JERUSALEM_i$, $CENTER_i$, $KRAYOT_i$, $SHARON_i$, and TEL_AVIV_i. (dummy variables that equal 1 if dwelling unit is located in the North, Gush Dan, South, Jerusalem, Center, Krayot, Sharon, and Tel Aviv regions, respectively, and 0 otherwise). The matrix X_2 includes: $AREA_i$ (dwelling unit area in square feet); $ROOMS_i$ (number of rooms in the unit); $FLOOR_i$ (the floor on which unit is located for condominiums and zero if detached unit); $STORIES_i$ (number of stories in the structure where the unit is located); $ELEVATOR_i$ (elevator in the structure = 1 and 0 otherwise); $SHELTERS_i$ (number of bomb shelters in the structure); $ENTRANCES_i$ (number of entrances to the structure); $STRUCT\_AGE_i$ (structure age in years at the date of purchase or at the end of the sample period if not purchased); and $STRUCT\_PER_i$ (the percentage share of units in the structure that are publicly-owned). Finally, γ_1 and γ_2 are vectors of parameters and $u_{1,i}$ is the random disturbance term.

The sample for Equation (3) includes the entire population of purchasers and non-purchasers who reported income to the authorities—a total of 35,825 households (of which 26,606 are nondisabled and 9,219 are disabled tenants). The dependent variable is $INCOME_i$, the level of current income and $\phi\left(z_i^*\right)$ and $\Phi\left(z_i^*\right)$ are the normal density and the cumulative normal density of the likelihood to file an income tax report on the household's level of income generated from the estimation of Equation (2), where $\left[\phi\left(z_i^*\right)/\Phi\left(z_i^*\right)\right]$ is the inverse-mills ratio. The matrix X_1 includes the same household sociodemographic-locational characteristics described above, γ_3 is a vector of parameters, and $u_{2,i}$ is a random disturbance term.

Equations (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 concern is that the $INCOME$ term may be censored as some households in our sample avoid reporting their income (low-income households in Israel are generally exempted from filing tax returns—see footnote 13). Finally, our sample of purchasers may be subject to selection bias due to difficulties of low-income renter households in affording and financing the purchase of a dwelling unit. Consequently, the Heckman correction is required.[19] Because the level of income is also potentially positively correlated with the decision to purchase the dwelling unit, the use of

18. We also estimated a model where all explanatory variables (including all control variables) are stratified by D_i. Results were robust to this fully unconstrained variation.

19. The positive and significant Inverse-Mills ratio obtained in the estimation procedure (estimated coefficient of 1,164 and standard error of 135.9) supports the hypothesis of selection bias addressed via this procedure. Also, current annual income of purchasers turns out to be $1,951 higher than non-purchasers—the difference is significant at the 1% level ($t = 24.93$).

the purchase decision as the selection criteria is appropriate.

In sum, based on the Heckman selection procedure in Equation (2), we generate a vector of projected income values in Equation (3), which estimates the permanent income of each tenant in the full sample. We then incorporate this vector into the unbalanced panel of 6,853 buyers in Equation (1). In that manner, we address the disincentive of high-income tenants to report their income level. Furthermore, we address the concern that current income may be a poor proxy for permanent income (also, note that the model's structure permits over identification of both Equations (1) and (3)).

Given the system of Equations (1)–(3), and prior to assessment of loss aversion among the nondisabled and disabled populations, we seek to verify that tenants indeed account for the reference reduction rate in their home purchase decision. In other words, we test that the coefficients of $REF_{i,t} \times Sign$ and $(RED_{i,t} - REF_{i,t}) \times Sign$ do not cancel out (note that adding these terms together with the same coefficient nullifies the $REF_{i,t}$ variable). Our initial step thus tests the corresponding three joint null hypotheses: $\alpha_1 + \alpha_7 \times D_i = -(\alpha_4 + \alpha_{10} \times D_i)$, $\alpha_2 + \alpha_8 \times D_i = \alpha_5 + \alpha_{11} \times D_i$, and $\alpha_3 + \alpha_9 \times D_i = 0$.[20] A failure to reject these null hypotheses implies that the coefficients of the corresponding $REF_{i,t} \times Sign$ and $(RED_{i,t} - REF_{i,t}) \times Sign$ cancel out for all $Sign = \{NEG_{i,t}, POS_{i,t}, (1 - NEG_{i,t})(1 - POS_{i,t})\}$ such that the $REF_{i,t} \times Sign$ term disappears and only the $RED_{i,t} \times Sign$ term remains.

We test for loss aversion among the nondisabled and disabled groups by focusing on their asymmetric purchase response to losses and gains in programmatic price reductions. Particularly, we compute the "loss-gain ratio," $|(\alpha_4/\alpha_5)|$ and $|(\alpha_4 + \alpha_{10}D_i)/(\alpha_5 + \alpha_{11}D_i)|$ for the nondisabled and the disabled populations, respectively. A ratio equal to 1 implies no loss aversion, whereas the greater the ratio in excess of 1, the larger the degree of loss aversion. As discussed above, we hypothesize that the degree of loss aversion among the nondisabled group is higher than that of the disabled group.

20. Note that in the case of $NEG_{i,t} = 1$, the absolute value function transforms $RED_{i,t} - REF_{i,t} < 0$ from negative to positive value. Therefore, and unlike the case of $RED_{i,t} - REF_{i,t} > 0$ (where the absolute value remains positive) the null is $\alpha_1 + \alpha_7 \times D_i = -(\alpha_4 + \alpha_{10} \times D_i)$.

V. ASYMMETRIC RESPONSE TO LOSSES AND GAINS AND THE DEGREE OF DISABILITY

Section 1 of Table 3 presents the parameter estimates obtained from the Cox regression estimation of Equation (1) (results of estimation of Equations (2) and (3) are displayed in Appendix D). As described above, we first test whether households take into account the reference reduction rate in timing of home purchase. As shown, the null hypothesis that households do not account for the reference rate is rejected at a 1% significance level for both the nondisabled ($D_i = 0$) and the disabled (with 100% disability, i.e., $D_i = 100$) groups (also, rejection of the null hypothesis is obtained for the case of $D_i = 50$ [not reported in the table]).

Also, in section 2 of Table 3, we compute the loss-gain ratio for the nondisabled and the disabled groups based solely on significant coefficients. Figure 2 graphs the computed loss-gain ratio across the disability index. The loss-gain ratio for nondisabled equals 4.55, implying that, on average, a 1% *decrease* in the current reduction rate relative to the reference reduction rate *discourages* a purchase in the same manner that a 4.55% *increase* in those figures *encourages* a purchase. Interestingly, the projected loss-gain ratio after substituting $D_i = 100$ (100% disability index) is only 2.92. Moreover, the ratio 4.55/2.92 is significantly different from 1 at the 1% level ($\chi^2 = 37.99$ with 1 *df*). Similar rejection is obtained for the case of 50% disability ($D_i = 50$). In this case (not reported in the table), the loss-gain ratio of 4.55/3.55 is significantly different from 1 at the 1% level. Results thus show that the asymmetry associated with losses and gains declines with degree of disability.

VI. ROBUSTNESS TESTS

In this section, we assess the robustness of our findings to issues of sampling and test design. Specifically, we below address sensitivity of results to four key elements of our empirical approach, including focus on a particular reference rate of price reduction, sample of disabled population, sample of nondisabled population, and sample of purchasers only.

To further gage the sensitivity of our findings to choice of reference price reduction rate, we reestimate Equation (1) substituting the *initial* reduction rate faced by tenant i at time $t = 1$, REF_i^{First}, for the *average* reduction rate across all prior $t - 1$ periods as utilized in the analysis.

TABLE 3

Testing Loss Aversion in Nondisabled and Disabled Groups with the Average Previous Reduction Rate as a Reference

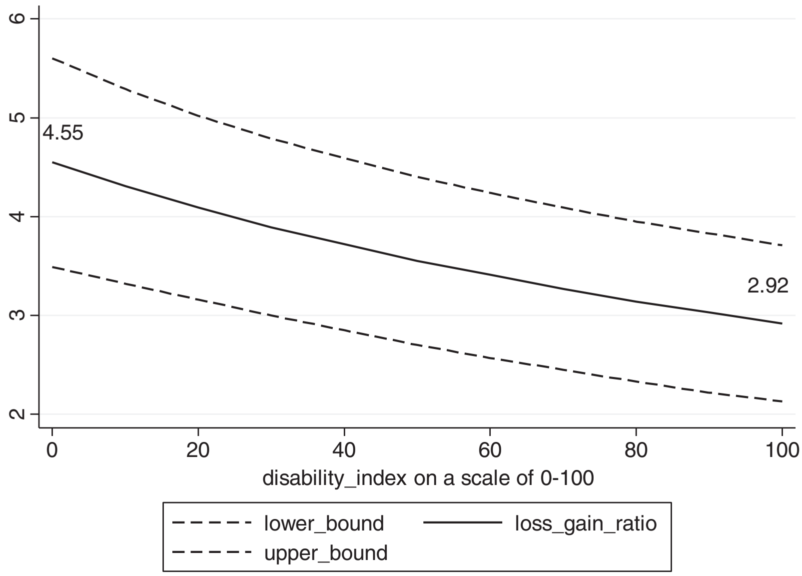
Variables	Coefficient	(1) Full Model	(2) Stepwise
Section 1: regression outcomes			
$REF_{i,t} \times NEG_{i,t}$	α_1	0.03^{***}	0.03^{***}
		(6.85×10^{-4})	(6.65×10^{-4})
$REF_{i,t} \times POS_{i,t}$	α_2	0.04^{***}	0.04^{***}
		(2.52×10^{-3})	(2.48×10^{-3})
$REF_{i,t} \times (1 - NEG_{i,t}) \times (1 - POS_{i,t})$	α_3	0.04^{***}	0.04^{***}
		(1.20×10^{-3})	(1.18×10^{-3})
$\lvert RED_{i,t} - REF_{i,t} \rvert \times NEG_{1,i,t}$	α_4	-0.11^{***}	-0.11^{***}
		(9.36×10^{-3})	(9.23×10^{-3})
$\lvert RED_{i,t} - REF_{i,t} \rvert \times POS_{1,i,t}$	α_5	0.02^{***}	0.02^{***}
		(1.01×10^{-3})	(1.00×10^{-3})
D_i	α_6	-0.01^{***}	-0.01^{***}
		(2.20×10^{-3})	(9.52×10^{-4})
$REF_{i,t} \times NEG_{i,t} \times D_i$	α_7	1.98×10^{-5}	—
		(2.91×10^{-5})	—
$REF_{i,t} \times POS_{i,t} \times D_i$	α_8	2.81×10^{-4}	—
		(2.90×10^{-4})	—
$REF_{i,t} \times (1 - NEG_{i,t}) \times (1 - POS_{i,t}) \times D_i$	α_9	6.86×10^{-5}	—
		(9.18×10^{-5})	—
$\lvert RED_{i,t} - REF_{i,t} \rvert \times NEG_{i,t} \times D_i$	α_{10}	-1.15×10^{-4}	—
		(6.70×10^{-4})	—
$\lvert RED_{i,t} - REF_{i,t} \rvert \times POS_{i,t} \times D_i$	α_{11}	$1.54 \times 10^{-4***}$	$1.34 \times 10^{-4***}$
		(2.94×10^{-5})	(2.00×10^{-5})
$AVG\_RED_{,t}$	α_{12}	-0.01	—
		(8.85×10^{-3})	—
$RENT\_NET_{i,t}$	α_{13}	$1.21 \times 10^{-4***}$	$1.20 \times 10^{-4***}$
		(1.86×10^{-5})	(1.86×10^{-5})
ΔSTD_t	α_{14}	0.16	—
		(0.19)	—
$PROJ(INCOME)_i$	α_{15}	$-1.83 \times 10^{-5***}$	$-1.88 \times 10^{-5***}$
		(6.59×10^{-6})	(6.56×10^{-6})
$\Delta MORTGAGE_t$	α_{16}	7.54×10^{-4}	—
		(0.52)	—
$APPRECIATION_{i,t}$	α_{17}	$1.88 \times 10^{-2***}$	$1.87 \times 10^{-2***}$
		(3.75×10^{-3})	(3.73×10^{-3})
$ELEVATOR_i$	α_{18}	-0.05	—
		(0.04)	—
$DETACHED_i$	α_{19}	0.03	—
		(0.04)	—
$STRUCT\_AGE_i$	α_{20}	-0.02^{***}	-0.02^{***}
		(1.59×10^{-3})	(1.50×10^{-3})
$ROOMS_i$	α_{21}	-0.13^{***}	-0.13^{***}
		(1.75×10^{-2})	(1.62×10^{-2})
Number of nondisabled households		6,543	6,543
Number of disabled households		310	310
Chi-square statistics		4560	4525
Log likelihood		−51206	−51208
Section 2: loss-gain ratios and statistical tests			
Loss-gain ratio	$\left\lvert \frac{\alpha_4}{\alpha_5} \right\rvert (D_i = 0)$		4.55
Loss-gain ratio	$\left\lvert \frac{\alpha_4}{\alpha_5 + \alpha_{11} D_i} \right\rvert (D_i = 100)$		2.92
Chi-square value from testing	$\left\lvert \frac{\alpha_4}{\alpha_5 + \alpha_{11} D_i} \right\rvert_{D_i = 0} = \left\lvert \frac{\alpha_4}{\alpha_5 + \alpha_{11} D_i} \right\rvert_{D_i = 100}$		37.99^{***}

Notes: The table displays the outcomes obtained from the Cox regressions. The Breusch-Pagan test rejects the null hypothesis that random disturbance terms are homoscedastic with respect to the independent variables for the full model. Calculated chi-squared value of 644.87 is significant at the 1% level (the 1% critical $\chi^2 = 38.93$ with 21 *df*). Consequently, robust standard errors are given in parentheses. Also, we reject the joint hypothesis that (1) $\alpha_1 + \alpha_7 \times D_i = -(\alpha_4 + \alpha_{10} \times D_i)$; (2) $\alpha_2 + \alpha_8 \times D_i = \alpha_5 + \alpha_{11} \times D_i$; and (3) $\alpha_3 + \alpha_9 \times D_i = 0$ at the 1% level ($\chi^2 = 465$ and 361 for $D_i = 0$ and 100, respectively). The box includes the coefficients through which we calculate the loss-gain ratio at the lower part of each table.

**Significant at 5%; ***significant at 1%.

FIGURE 2

Loss-Gain Ratio across Disability Index with the Average Previous Reduction Rate as a Reference



Notes: The loss-gain ratio is based on results given in Table 3 and obtained from the model with control variables and the sample of 6,543 nondisabled and 310 disabled buyers (212 who are either confined to a wheelchair or suffer from polio and 98 whose disability source is unknown). It is given by $|(\alpha_4)/(\alpha_5 + \alpha_{11} D_i)|$, where $0 \le D_i \le 100$. The lower and upper bounds are the 99% confidence intervals. The loss-gain ratio 4.55/2.92 is significantly different from 1 at the 1% level (calculated $\chi^2 = 37.99$ with 1 *df*).

Results are presented in Table 4. Findings indicate that the disabled remain significantly less loss averse. Specifically, use of the above alternative price reduction rate results in a loss-gain ratio of 2.38 for nondisabled and 1.85 for disabled population when substituting $D_i = 100\%$. The ratio 2.38/1.85 is significantly different from 1 at the 1% level ($\chi^2 = 24.28$).

In another robustness test, we substitute the running *maximum* price reduction rate across all prior $t-1$ periods, $REF^{Max}_{i,t}$, as the reference reduction rate in place of the average reduction rate $REF_{i,t}$. This substitution increases the frequency of purchases at a loss (compared to the reference reduction rate) to 48 cases. We then reestimate the following variation of Equation (1) for each of the nondisabled and disabled groups:

$$\text{(1a)} \quad h(t) = h_{01}(t) \exp[\delta_2 REF^{Max}_{i,t} \times NEG_{i,t} + \delta_3 REF^{Max}_{i,t} \times \left(1 - NEG_{i,t}\right) + \delta_5 \left| RED_{i,t} - REF^{Max}_{i,t} \right| \times NEG_{i,t} + \psi_{1,i,t}],$$

where $REF^{Max}_{i,t}$ is i's maximum price reduction rate across all prior $t-1$ periods and other variables are as described above (due to lack of degrees of freedom we omit the *CONTROL* matrix from this estimation). Results of the estimation of Equation (1a) are reported in Table 5. Findings indicate that the coefficient on $\left| RED_{i,t} - REF^{Max}_{i,t} \right| \times NEG_{i,t}$ is negative and significant at the 1% level for both the nondisabled and disabled populations. Moreover, note the difference in this coefficient between the nondisabled and disabled groups: a 1% increase in the absolute value of the difference between the current and the reference reduction rates is associated with a 6.38% and 4.12% decrease in the hazard rate of option exercise for the nondisabled and disabled groups, respectively. These figures are signficantly different from one another at the 5% level. Results thus indicate a lower degree of loss aversion among the disabled population both on the gain and loss sides.

Note that for the 310 disabled households in our sample, we have information of source of disability only for 212 observations. In that regard,

TABLE 4
Testing Loss Aversion in Nondisabled and Disabled Groups with the First Reduction Rate as a Reference

Variables	Coefficient	(1) Full Model	(2) Stepwise
Section 1: regression outcomes			
$REF_i^{First} \times NEG_{i,t}$	α_1	0.04^{***}	0.04^{***}
		(1.05×10^{-3})	(1.03×10^{-3})
$REF_i^{First} \times POS_i$	α_2	0.03^{***}	0.03^{***}
		(6.70×10^{-4})	(6.41×10^{-4})
$REF_i^{First} \times (1 - NEG_{i,t}) \times (1 - POS_{i,t})$	α_3	0.04^{***}	0.04^{***}
		(2.26×10^{-3})	(2.24×10^{-3})
$\lvert RED_{i,t} - REF_i^{First} \rvert \times NEG_{1,i,t}$	α_4	$-7.56 \times 10^{-2***}$	$-7.54 \times 10^{-2***}$
		(3.24×10^{-3})	(3.20×10^{-3})
$\lvert RED_{i,t} - REF_i^{First} \rvert \times POS_{1,i,t}$	α_5	$3.15 \times 10^{-2***}$	$3.17 \times 10^{-2***}$
		(6.83×10^{-4})	(6.44×10^{-4})
D_i	α_6	-0.01^{***}	-0.01^{***}
		(2.06×10^{-3})	(1.04×10^{-3})
$REF_i^{First} \times NEG_{i,t} \times D_i$	α_7	1.59×10^{-6}	—
		(6.65×10^{-5})	—
$REF_i^{First} \times POS_{i,t} \times D_i$	α_8	2.00×10^{-5}	—
		(2.98×10^{-5})	—
$REF_i^{First} \times (1 - NEG_{i,t}) \propto (1 - POS_{i,t}) \times D_i$	α_9	2.86×10^{-4}	—
		(2.77×10^{-4})	—
$\lvert RED_{i,t} - REF_i^{First} \rvert \times NEG_{i,t} \times D_i$	α_{10}	9.91×10^{-5}	—
		(2.38×10^{-4})	—
$\lvert RED_{i,t} - REF_i^{First} \rvert \times POS_{i,t} \times D_i$	α_{11}	$1.10 \times 10^{-4***}$	$9.12 \times 10^{-5***}$
		(2.68×10^{-5})	(1.80×10^{-5})
$AVG\_RED_{,t}$	α_{12}	-0.01	—
		(8.87×10^{-3})	—
$RENT\_NET_{i,t}$	α_{13}	$1.15 \times 10^{-4***}$	$1.14 \times 10^{-4***}$
		(1.85×10^{-5})	(1.83×10^{-5})
ΔSTD_t	α_{14}	0.14	—
		(0.19)	—
$PROJ(INCOME)_i$	α_{15}	-3.33×10^{-6}	—
		(6.74×10^{-6})	—
$\Delta MORTGAGE_t$	α_{16}	0.03	—
		(0.52)	—
$APPRECIATION_{i,t}$	α_{17}	0.02^{***}	0.02^{***}
		(3.75×10^{-3})	(3.72×10^{-3})
$ELEVATOR_i$	α_{18}	-0.07^{*}	—
		(0.04)	—
$DETACHED_i$	α_{19}	0.06	—
		(0.04)	—
$STRUCT\_AGE_i$	α_{20}	-0.02^{***}	-0.02^{***}
		(1.56×10^{-3})	(1.47×10^{-3})
$ROOMS_i$	α_{21}	-0.13^{***}	-0.13^{***}
		(1.72×10^{-2})	(1.57×10^{-2})
Regression statistics:			
Nondisabled households		6,543	6,543
Disabled households		310	310
Chi-square statistic		4877	4826
Log likelihood		−51233	−51237
Section 2: loss-gain ratios and statistical tests			
Loss-gain ratio	$\left\lvert \frac{\alpha_4}{\alpha_5} \right\rvert (D_i = 0)$		2.38
Loss-gain ratio	$\left\lvert \frac{\alpha_4}{\alpha_5 + \alpha_{11} D_i} \right\rvert (D_i = 100)$		1.85
Chi square value from testing	$\left\lvert \frac{\alpha_4}{\alpha_5 + \alpha_{11} D_i} \right\rvert_{D_i=0} = \left\lvert \frac{\alpha_4}{\alpha_5 + \alpha_{11} D_i} \right\rvert_{D_i=100}$		24.28^{***}

Notes: The table displays the outcomes obtained from the Cox regressions, where REF_i^{First} variable is the first reduction rate the tenant encounters at $t = 0$. The Breusch-Pagan test rejects the null hypothesis that random disturbance terms are homoscedastic with respect to the independent variables for the full model. Calculated chi-squared value of 625.68 is highly significant at the 1%-level (the 1% critical $\chi^2 = 38.93$ with 21 *df*). Consequently, robust standard errors are given in parentheses. Also we reject the joint hypothesis that (1) $\alpha_1 + \alpha_7 \times D_i = -(\alpha_4 + \alpha_{10} \times D_i)$; (2) $\alpha_2 + \alpha_8 \times D_i = \alpha_5 + \alpha_{11} \times D_i$; and (3) $\alpha_3 + \alpha_9 \times D_i = 0$ at the 1% level ($\chi^2 = 506$ and 529 for $D_i = 0$ and 100, respectively). The box includes the coefficients through which we calculate the loss-gain ratio at the lower part of each table.

**Significant at 5%; ***significant at 1%.

TABLE 5
Testing Loss Aversion in Nondisabled and Disabled Groups with Previous Maximum Reduction Rate as a Reference

Variables	Coefficient	(1) Nondisabled Group	(2) Disabled Group
$REF_{i,t}^{Max} \times NEG_{i,t}$	δ_2	0.03^{***}	0.02^{***}
		(9.03×10^{-4})	(4.14×10^{-3})
$REF_{i,t}^{Max} \times (1 - NEG_{i,t})$	δ_3	0.03^{***}	0.03^{***}
		(5.47×10^{-4})	(3.10×10^{-3})
$\lvert RED_{i,t} - REF_{i,t}^{Max} \rvert \times NEG_{i,t}$	δ_5	-0.06^{***}	-0.04^{***}
		(2.79×10^{-3})	(1.12×10^{-2})
Regression statistics:			
Observations		290,869	23,971
Subjects		6,543	310
Chi-square statistic		3895	267.8
Log likelihood		−48883	−1369
Test of hypothesis that δ_5 is equal for nondisabled and disabled groups	H_0: $\delta_{5,(1)} = \delta_{5,(2)}$	—	5.90^{**}

Notes: The table displays the outcomes obtained from the Cox regressions. The $REF_{i,t}^{Max}$ variable is the running maximum among all prior reduction rates (excluding the current reduction rate). Columns (1) and (2) refer to nondisabled and disabled households, respectively. The Breusch-Pagan tests reject the null hypothesis that random disturbance terms are homoscedastic with respect to the independent variables for both pooled samples (i.e., the pooled sample of columns (1) and (2)). Calculated chi-squared value of 205.59 is highly significant at the 1% level (the 1% critical $\chi^2 = 16.81$ with 6 *df*). Consequently, robust standard errors are given in parentheses. The box includes the coefficients through which we calculate the loss-gain ratio at the lower part of each table.

**Significant at 5%; ***significant at 1%.

we know that all of the 212 surveyed households are either confined to a wheelchair and/or victims of polio. For the remaining 98 observations, the source of disability is not indicated in the sample. We accordingly reestimate the model using only those households for whom the source of disability is known. We run this estimation for both $REF_{i,t}$ and REF_i^{First}.

As shown in Table 6, results are largely robust to choice of sample. In the case of $REF_{i,t}$, the loss-gain ratio equals 4.55 for the nondisabled group and 2.59 for the disabled group with known physical disability (compared to 4.55 for the nondisabled population, and 2.92 figure for the entire disabled population, as previously reported). In the case of REF_i^{First}, the loss-gain ratio equals 2.37 for the nondisabled group and 1.66 for the disabled group with known physical disability (compared to 2.38 and 1.85 for the entire nondisabled and disabled populations, respectively).

To further assess the robustness of results, we restrict the sample of nondisabled households to include only those living in the same type of units as included for the disabled population (e.g., detached units, first-floor condominium units, or any condominium unit in buildings with an elevator). Again, we reestimate the model twice—once with $REF_{i,t}$ and then with REF_i^{First} as the specified reference price reduction rate. As shown in Table 7, findings again are largely robust to this change in sampling. In the case of $REF_{i,t}$, the loss-gain ratios for the nondisabled and disabled populations (100% disability) are 4.41 and 2.71, respectively; these values are significantly different from one another at the 1% level. With REF_i^{First}, these figures drop to 2.26 and 1.73, respectively, where again the figures are significantly different from one another at the 1% level.

Finally, recall that our analysis focuses on timing of purchase among the subset of public housing tenants that exercised the purchase option at some point during the program period. As noted above, our focus on purchasers only seeks to address a potential sample selection bias, as some tenants may have failed to purchase their dwelling due to income constraints. An additional robustness test thus seeks to expand our sample as to include tenants who were not bound by affordability constraints but otherwise chose not to purchase.

TABLE 6
Testing Loss-Aversion for Nondisabled and Disabled with Known Physical Disability Only

VARIABLES	Coefficient	Case (1) $REF = REF_{i,t}$	Case (2) $REF = REF_i^{First}$
Section 1: regression outcomes			
$REF \times NEG_{i,t}$	α_1	0.03^{***}	0.04^{***}
		(6.75×10^{-4})	(1.04×10^{-3})
$REF \times POS_{i,t}$	α_2	0.04^{***}	0.03^{***}
		(2.51×10^{-3})	(6.47×10^{-4})
$REF \times (1 - NEG_{i,t}) \times (1 - POS_{i,t})$	α_3	0.04^{***}	0.04^{***}
		(1.19×10^{-3})	(2.25×10^{-3})
$\lvert RED_{i,t} - REF \rvert \times NEG_{i,t}$	α_4	-0.11^{***}	-0.08^{***}
		(9.32×10^{-3})	(3.23×10^{-3})
$\lvert RED_{i,t} - REF \rvert \times POS_{i,t}$	α_5	0.02^{***}	0.03^{***}
		(1.01×10^{-3})	(6.48×10^{-4})
D_i	α_6	-0.02^{***}	-0.02^{***}
		(9.34×10^{-4})	(1.13×10^{-3})
$REF \times NEG_{i,t} \times D_i$	α_7	—	—
		—	—
$REF \times POS_{i,t} \times D_i$	α_8	—	—
		—	—
$REF \times (1 - NEG_{i,t}) \times (1 - POS_{i,t}) \times D_i$	α_9	—	—
		—	—
$\lvert RED_{i,t} - REF \rvert \times NEG_{i,t} \times D_i$	α_{10}	—	—
		—	—
$\lvert RED_{i,t} - REF \rvert \times POS_{i,t} \times D_i$	α_{11}	$1.82 \times 10^{-4***}$	$1.36 \times 10^{-4***}$
		(3.03×10^{-5})	(1.90×10^{-5})
$AVG\_RED_{,t}$	α_{12}	—	—
		—	—
$RENT\_NET_{i,t}$	α_{13}	$1.20 \times 10^{-4***}$	$1.12 \times 10^{-4***}$
		(1.87×10^{-5})	(1.84×10^{-5})
ΔSTD_t	α_{14}	—	—
		—	—
$PROJ(INCOME)_i$	α_{15}	$-2.12 \times 10^{-5***}$	—
		(6.62×10^{-6})	—
$\Delta MORTGAGE_t$	α_{16}	—	—
		—	—
$APPRECIATION_{i,t}$	α_{17}	0.02^{***}	0.02^{***}
		(3.74×10^{-3})	(3.73×10^{-3})
$ELEVATOR_i$	α_{18}	—	—
		—	—
$DETACHED_i$	α_{19}	—	—
		—	—
$STRUCT\_AGE_i$	α_{20}	-0.02^{***}	-0.02^{***}
		(1.51×10^{-3})	(1.48×10^{-3})
$ROOMS_i$	α_{21}	-0.13^{***}	-0.13^{***}
		(0.02)	(0.02)
Regression statistics:			
Number of nondisabled households		6,543	6,543
Number of disabled households		212	212
Chi-square statistics		4511	4766
Log likelihood		−50377	−50407
Section 2: loss-gain ratios and statistical tests			
Loss-gain ratio	$\left\lvert \frac{\alpha_4}{\alpha_5} \right\rvert (D_i = 0)$	4.55	2.37
Loss-gain ratio	$\left\lvert \frac{\alpha_4}{\alpha_5 + \alpha_{11} D_i} \right\rvert (D_i = 100)$	2.59	1.66
Chi-square value from testing	$\left\lvert \frac{\alpha_4}{\alpha_5 + \alpha_{11} D_i} \right\rvert_{D_i=0} = \left\lvert \frac{\alpha_4}{\alpha_5 + \alpha_{11} D_i} \right\rvert_{D_i=100}$	65.28^{***}	47.56^{***}

Notes: The table displays the outcomes obtained from the Cox regressions. $REF_{i,t}$ is the average reduction rate across all prior $(t-1)$ reduction rates starting from $t = 1$ and REF_i^{First} is the first reduction rate the tenant faces at $t = 1$. Physically disabled households are households whose source of disability is known in the data (head-of-household or spouse are either confined to a wheelchair or suffer from polio). The Breusch-Pagan tests reject the null hypothesis that random disturbance terms are homoscedastic with respect to the independent variables for the full model. Calculated chi-squared values of 609.30 and 612.68 are highly significant at the 1% level (the 1% critical $\chi^2 = 38.93$ with 21 *df*). Consequently, robust standard errors are given in parentheses. Also we reject the joint hypothesis that (1) $\alpha_1 + \alpha_7 \times D_i = -(\alpha_4 + \alpha_{10} \times D_i)$; (2) $\alpha_2 + \alpha_8 \times D_i = \alpha_5 + \alpha_{11} \times D_i$; and (3) $\alpha_3 + \alpha_9 \times D_i = 0$ at the 1% level (for the case where $REF = REF_{i,t}$ $\chi^2 = 457$ and 361 for $D_i = 0$ and 100, respectively; and for the case where $REF = REF_i^{First}$ $\chi^2 = 495$ and 536 for $D_i = 0$ and 100, respectively). The box includes the coefficients through which we calculate the loss-gain ratio at the lower part of each table.

***Significant at 1%.

TABLE 7

Testing Loss-Aversion for Nondisabled and Disabled Populations Residing in Either Detached Units, First-Floor Condominium Units, or Any Floor of Condominium Units with an Elevator

Variables	Coefficient	Case (1) $REF = REF_{i,t}$	Case (2) $REF = REF_i^{First}$
Section 1: regression outcomes			
$REF \times NEG_{i,t}$	α_1	0.04^{***}	0.04^{***}
		(9.84×10^{-4})	(1.69×10^{-3})
$REF \times POS_{i,t}$	α_2	0.04^{***}	0.03^{***}
		(3.66×10^{-3})	(9.48×10^{-4})
$REF \times (1 - NEG_{i,t}) \times (1 - POS_{i,t})$	α_3	0.04^{***}	0.04^{***}
		(1.86×10^{-3})	(3.07×10^{-3})
$\lvert RED_{i,t} - REF \rvert \times NEG_{1,i,t}$	α_4	-0.10^{***}	-0.07^{***}
		(0.01)	(4.70×10^{-3})
$\lvert RED_{i,t} - REF \rvert \times POS_{1,i,t}$	α_5	0.02^{***}	0.03^{***}
		(1.42×10^{-3})	(9.63×10^{-4})
D_i	α_6	-0.01^{***}	-0.01^{***}
		(1.01×10^{-3})	(1.09×10^{-3})
$REF \times NEG_{i,t} \times D_i$	α_7	—	—
		—	—
$REF \times POS_{i,t} \times D_i$	α_8	—	—
		—	—
$REF \times (1 - NEG_{i,t}) \times (1 - POS_{i,t}) \times D_i$	α_9	—	—
		—	—
$\lvert RED_{i,t} - REF \rvert \times NEG_{i,t} \times D_i$	α_{10}	—	—
		—	—
$\lvert RED_{i,t} - REF \rvert \times POS_{i,t} \times D_i$	α_{11}	$1.46 \times 10^{-4***}$	$9.77 \times 10^{-5***}$
		(2.15×10^{-5})	(1.94×10^{-5})
$AVG\_RED_{,t}$	α_{12}	—	—
		—	—
$RENT\_NET_{i,t}$	α_{13}	$1.26 \times 10^{-4***}$	$1.25 \times 10^{-4***}$
		(2.66×10^{-5})	(2.60×10^{-5})
ΔSTD_t	α_{14}	—	—
		—	—
$PROJ(INCOME)_i$	α_{15}	—	—
		—	—
$\Delta MORTGAGE_t$	α_{16}	—	—
		—	—
$APPRECIATION_{i,t}$	α_{17}	—	—
		—	—
$ELEVATOR_i$	α_{18}	—	—
		—	—
$DETACHED_i$	α_{19}	—	—
		—	—
$STRUCT\_AGE_i$	α_{20}	-0.02^{***}	-0.02^{***}
		(1.97×10^{-3})	(1.91×10^{-3})
$ROOMS_i$	α_{21}	-0.12^{***}	-0.11^{***}
		(0.02)	(0.02)
Regression statistics:			
Number of nondisabled households		2,872	2,872
Number of disabled households		310	310
Chi-square statistics		2,254	2,372
Log likelihood		−21243	−21268
Section 2: loss-gain ratios and statistical tests			
Loss-gain ratio	$\left\lvert \frac{\alpha_4}{\alpha_5} \right\rvert (D_i = 0)$	4.41	2.26
Loss-gain ratio	$\left\lvert \frac{\alpha_4}{\alpha_5 + \alpha_{11} D_i} \right\rvert (D_i = 100)$	2.71	1.73
Chi-square value from testing	$\left\lvert \frac{\alpha_4}{\alpha_5 + \alpha_{11} D_i} \right\rvert_{D_i=0} = \left\lvert \frac{\alpha_4}{\alpha_5 + \alpha_{11} D_i} \right\rvert_{D_i=100}$	32.99^{***}	22.88^{***}

Notes: The table displays the outcomes obtained from the Cox regressions. $REF_{i,t}$ is the average reduction rate across all prior $(t-1)$ reduction rates starting from $t = 1$ and REF_i^{First} is the first reduction rate the tenant faces at $t = 1$. Physically disabled households are households whose head or spouse are either confined to a wheelchair or suffer from polio. The Breusch-Pagan tests reject the null hypothesis that random disturbance terms are homoscedastic with respect to the independent variables for the full model. Calculated chi-squared values of 290.11 and 289.79 are highly significant at the 1% level (the 1% critical $\chi^2 = 38.93$ with 21 *df*). Consequently, robust standard errors are given in parentheses. Also we reject the joint hypothesis that (1) $\alpha_1 + \alpha_7 \times D_i = -(\alpha_4 + \alpha_{10} \times D_i)$; (2) $\alpha_2 + \alpha_8 \times D_i = \alpha_5 + \alpha_{11} \times D_i$; and (3) $\alpha_3 + \alpha_9 \times D_i = 0$ at the 1% level (for the case where $REF = REF_{i,t}$ $\chi^2 = 259$ and 191 for $D_i = 0$ and 100, respectively; and for the case where $REF = REF_i^{First}$ $\chi^2 = 287$ and 302 for $D_i = 0$ and 100, respectively). The box includes the coefficients through which we calculate the loss-gain ratio at the lower part of each table.

***Significant at 1%.

To expand the sample in this manner, we assume a 25% monthly mortgage payment-to-income ratio as the upper limit for mortgage availability. For each of the nonpurchasers in our sample, we then compute a payment-to-income ratio assuming home purchase at the current price reduction rate using a 20-year, 100% loan-to-value mortgage.[21] We then incorporate in our sample all nonpurchasing tenants whose computed payment-to-income ratio is not greater than 25%. This procedure yields a total of 705 additional observations, 110 of which are added to the disabled sample population.

Expansion of the sample in this manner serves to reduce the loss-gain ratio for both nondisabled and disabled groups (see Table 8). The loss-gain ratio now equals 3.25 for the nondisabled group and 2.30 for the disabled group when substituting $D_i = 100\%$; however, the ratio 3.25/2.30 remains significantly different from 1 at the 1% significance level ($\chi^2 = 53.32$). We repeat this exercise substituting the first reduction rate for the average of prior price reduction rates. Again, the loss-gain ratio for the nondisabled (disabled group when substituting $D_i = 100\%$) is 2.33 (1.73) where the figures are different from one another at the 1% significance level.

VII. LOSS AVERSION AND DEMOGRAPHICS

In this section, we explore the sensitivity of the loss-gain ratio to demographic characteristics of nondisabled and disabled populations. Specifically, we focus on marital status and age of household head. Appendix E shows the methodology by which we test the sensitivity of the loss-gain ratio to marital status and age among nondisabled and disabled populations.

Figure 3 graphs the computed loss-gain ratio across the disability index for married and nonmarried households.[22] Note first that the loss-gain ratio trends down with disability status for both married and unmarried tenants. Moreover, unmarried households are significantly less loss averse than their married counterparts among both the nondisabled and disabled households. Among nondisabled households, the loss-gain ratio declines from 5.65 for married households to 3.44 for unmarried households, where the difference is significant at the 1% level. For disabled households with 50% disability, the loss-gain ratio drops from 4.43 for married households to 2.94 for unmarried households, where the difference is significant at the 5% level. For disabled households with 100% disability, the loss-gain ratio drops from 3.64 for married households to 2.57 for unmarried households (the difference, however, is statistically insignificant).

In Figure 4, we graph the loss-gain ratio across age of household head for nondisabled and disabled (with 50% and 100% disability) households.[23] In contrast to experimental findings by Mather et al. (2012), our analysis indicates that loss aversion attenuates with age of household head (among both nondisabled and disabled groups). For the nondisabled population the loss-gain ratios are 7.04 at age 30, and 4.11 at age 60 with the difference being significant at the 1% level. For disabled households with 50% (100%) disability, the loss-gain ratio declines from 4.67 (3.49) at age 30 to 3.46 (2.99) at age 60. The declines in loss aversion for the 50% (100%) disability groups are significant at the 1% level (insignificant).

VIII. SUMMARY AND CONCLUSIONS

A large literature points to differences in cognitive bias among diverse populations. Little is known, however, about the economic decision-making and related biases of the physically disabled. Empirical findings in physiology and psychology show that disabled persons often

21. Borrowers could of course apply for lower mortgage installments with a 30-year, 80% LTV loan. Lower monthly payments, however, would imply a lower payment-to-income ratio, which would, in turn, imply that our affordability threshold attenuates. We thus choose harsher loan conditions as to generate an "upper-bound" on our affordability measure. Also, we apply hedonic price estimation using the observed prices of the purchased units to project the pre-reduction (market) price of the housing unit of non-purchasers. Results of this estimation are available from the authors upon request. Finally, as our income variable reflects one's income in November 2005 (see footnote 13), we deflate and inflate the per tenant income variable using the time-series of average current wage published by the Israel Central Bureau of Statistics.

22. The outcomes of the estimation are not presented and are available from the authors upon request.

23. Again, the outcomes of the estimation are not presented and are available from the authors upon request. Also, note that under the structure of Equation (1b) (in Appendix E), our computed loss-gain ratio, $\frac{|\theta_4|}{\theta_5}$, becomes $\frac{|\omega_4+\omega_{10}\times D_i+\omega_{16}\times HEAD\_AGE_i+\omega_{22}D_i\times HEAD\_AGE_i|}{\omega_5+\omega_{11}\times D_i+\omega_{17}\times HEAD\_AGE_i+\omega_{23}D_i\times HEAD\_AGE_i}$ after substitution of Equations (1b.4), (1b.5). Finally, note that to calculate the loss-gain ratio we use only significant coefficients. Consequently this ratio becomes $\left|\frac{\omega_4+\omega_{16}\times HEAD\_AGE_i}{\omega_5+\omega_{11}\times D_i+\omega_{23}D_i\times HEAD\_AGE_i}\right|$.

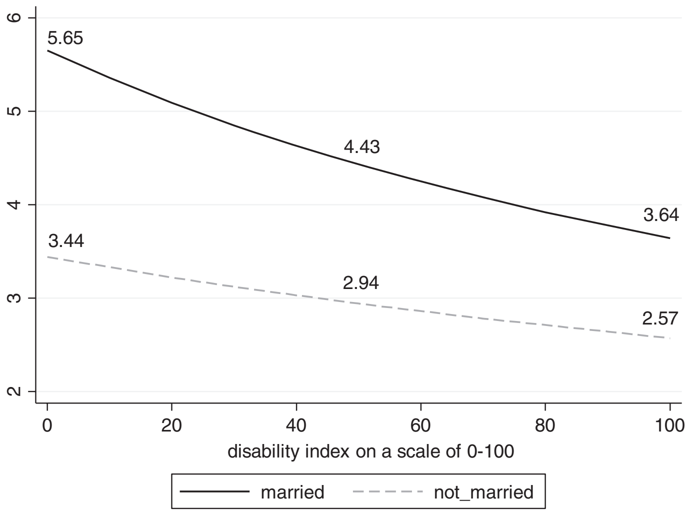
TABLE 8
Testing of Loss-Aversion Including Both Buyers and Augmented Renter Population

Variables	Coefficient	Case (1) $REF = REF_{i,t}$	Case (2) $REF = REF_i^{First}$
Section 1: regression outcomes			
$REF \times NEG_{i,t}$	α_1	0.03^{***}	0.03^{***}
		(6.57×10^{-4})	(1.10×10^{-3})
$REF \times POS_{i,t}$	α_2	0.04^{***}	0.03^{***}
		(2.51×10^{-3})	(6.30×10^{-4})
$REF \times (1 - NEG_{i,t}) \times (1 - POS_{i,t})$	α_3	0.03^{***}	0.03^{***}
		(1.28×10^{-3})	(2.25×10^{-3})
$\lvert RED - REF_{i,t} \rvert \times NEG_{1,i,t}$	α_4	-0.11^{***}	-0.08^{***}
		(9.37×10^{-3})	(3.67×10^{-3})
$\lvert RED - REF_{i,t} \rvert \times POS_{1,i,t}$	α_5	0.04^{***}	0.03^{***}
		(9.59×10^{-4})	(6.81×10^{-4})
D_i	α_6	-0.01^{***}	-0.01^{***}
		(8.80×10^{-4})	(1.17×10^{-3})
$REF \times NEG_{i,t} \times D_i$	α_7	—	$-1.05 \times 10^{-4}Z^{**}$
		—	(5.22×10^{-5})
$REF \times POS_{i,t} \times D_i$	α_8	—	—
		—	—
$REF \times (1 - NEG_{i,t}) \times (1 - POS_{i,t}) \times D_i$	α_9	$-1.43 \times 10^{-4**}$	—
		(6.76×10^{-5})	—
$\lvert RED_{i,t} - REF \rvert \times NEG_{i,t} \times D_i$	α_{10}	—	—
		—	—
$\lvert RED_{i,t} - REF \rvert \times POS_{i,t} \times D_i$	α_{11}	$1.45 \times 10^{-4***}$	$1.21 \times 10^{-4***}$
		(1.87×10^{-5})	(1.94×10^{-5})
$AVG\_RED_{,t}$	α_{12}	—	—
		—	—
$RENT\_NET_{i,t}$	α_{13}	$1.69 \times 10^{-4***}$	$1.62 \times 10^{-4***}$
		(1.86×10^{-5})	(1.92×10^{-5})
ΔSTD_t	α_{14}	—	—
		—	—
$PROJ(INCOME)_i$	α_{15}	—	$1.66 \times 10^{-5**}$
		—	(6.79×10^{-6})
$\Delta MORTGAGE_t$	α_{16}	—	—
		—	—
$APPRECIATION_{i,t}$	α_{17}	0.02^{***}	0.02^{***}
		(3.77×10^{-3})	(3.76×10^{-3})
$ELEVATOR_i$	α_{18}	—	—
		—	—
$DETACHED_i$	α_{19}	—	—
		—	—
$STRUCT\_AGE_i$	α_{20}	-0.03^{***}	-0.03^{***}
		(1.47×10^{-3})	(1.47×10^{-3})
$ROOMS_i$	α_{21}	-0.05^{***}	-0.05^{***}
		(0.02)	(0.02)
Number of nondisabled households		7,138	7,138
Number of disabled households		420	420
Chi-square statistics		5111	5357
Log likelihood		−52457	−52411
Section 2: loss-gain ratios and statistical tests			
Loss-gain ratio	$\left\lvert \frac{\alpha_4}{\alpha_5} \right\rvert (D_i = 0)$	3.25	2.33
Loss-gain ratio	$\left\lvert \frac{\alpha_4}{\alpha_5 + \alpha_{11} D_i} \right\rvert (D_i = 100)$	2.30	1.73
Chi square value from testing	$\left\lvert \frac{\alpha_4}{\alpha_5 + \alpha_{11} D_i} \right\rvert_{D_i=0} = \left\lvert \frac{\alpha_4}{\alpha_5 + \alpha_{11} D_i} \right\rvert_{D_i=100}$	53.32^{***}	36.88^{***}

Notes: The table displays the outcomes obtained from the Cox regressions. $REF_{i,t}$ is the average reduction rate across all prior $(t-1)$ reduction rates starting from $t = 1$ and REF_i^{First} is the first reduction rate the tenant faces at $t = 1$. The nonbuyer population in the sample maintains the condition that their potential payment-to-income ratio is no greater than 25% of household's deflated current income across all periods. The Breusch-Pagan tests reject the null hypothesis that random disturbance terms are homoscedastic with respect to the independent variables for the full model. Calculated chi-squared values of 1327.94 and 1098.18 are highly significant at the 1% level (the 1% critical $\chi^2 = 38.93$ with 21 *df*). Consequently, robust standard errors are given in parentheses. Also we reject the joint hypothesis that (1) $\alpha_1 + \alpha_7 \times D_i = -(\alpha_4 + \alpha_{10} \times D_i)$; (2) $\alpha_2 + \alpha_8 \times D_i = \alpha_5 + \alpha_{11} \times D_i$; and (3) $\alpha_3 + \alpha_9 \times D_i = 0$ at the 1% level (for the case where $REF = REF_{i,t}$ $\chi^2 = 365$ and 434 for $D_i = 0$ and 100, respectively; and for the case where $REF = REF_i^{First}$ $\chi^2 = 558$ and 584 for $D_i = 0$ and 100, respectively). The box includes the coefficients through which we calculate the loss-gain ratio at the lower part of each table.

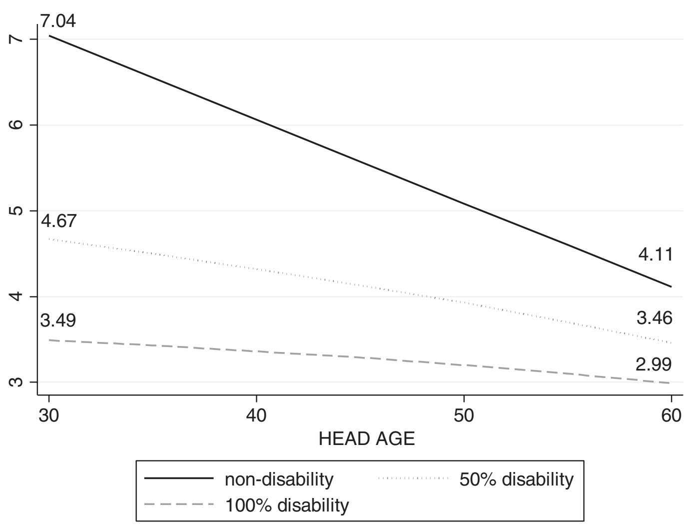
***Significant at 1%.

FIGURE 3
Loss-Gain Ratio Across Disability Index: Stratification by Marital Status



Notes: Based on significant coefficients obtained from step-wise Cox regressions, the loss-gain ratios are calculated by $|(\alpha_4)/(\alpha_5 + \alpha_{11} \times D_i)|$ separately for married and nonmarried, where $0 \leq D_i \leq 100$. The gray dashed (black solid) line refers to marital status of single, divorced, or widow (married). For the nondisabled group, the difference between 5.65 and 3.44 is statistically significant at the 1% level (calculated $\chi^2 = 7.05$ with 1 *df*). For 50% disabled, the difference between 4.43 and 2.94 is statistically significant at the 5% level (calculated $\chi^2 = 4.54$ with 1 *df*). Finally, for 100% disabled, the difference between 3.64 and 2.57 is insignificant (calculated $\chi^2 = 2.44$ with 1 *df*).

FIGURE 4
Loss-Gain Ratio: Stratification by Age of the Head of the Household



Notes: Based on significant coefficients obtained from step-wise Cox regressions, the loss-gain ratios are calculated by $|(\omega_4 + \omega_{16} \times HEAD\_AGE_i)/(\omega_5 + \omega_{11} \times D_i + \omega_{23} D_i \times HEAD\_AGE_i)|$, where D_i is the disability and $HEAD\_AGE_i$ is the age of head-of-household in years. The three lines given in the graph refer to: $D_i = 0$ (the black solid line), $D_i = 50$ (the dark gray dotted line), and $D_i = 100$ (the gray dashed line). For the nondisabled group, the difference between 7.04 and 4.11 is statistically significant at the 1% level (calculated $\chi^2 = 26.24$ with 1 *df*). For the 50% disability, the difference between 4.67 and 3.46 is statistically significant at the 1% level (calculated $\chi^2 = 8.85$ with 1 *df*). Finally, for the 100% disability group, the difference between 3.49 and 2.99 is insignificant (calculated $\chi^2 = 2.18$ with 1 *df*).

develop physical and psychological mechanisms to compensate for disabilities. Coping mechanisms, however, may not be limited to the psychophysiological domain and may extend to cognitive bias and loss aversion. Indeed, disability status may give rise to behavioral economic heuristics that differ from those of nondisabled persons. Similar to physical coping mechanisms, diminished cognitive bias could compensate for disability and provide disabled persons with improved coping prospects.

In this study, we test for differences in cognitive bias and behavioral heuristics among nondisabled and physically disabled populations. Specifically, we use microdata from a natural policy experiment to assess loss aversion in home purchase among the nondisabled and disabled households. Results show that while nondisabled households are 4.55 times more responsive to declines in house price reduction rates relative to comparable rate increases, that same loss-gain ratio falls to 2.92 for disabled households. Furthermore, loss aversion attenuates with degree of disability. Research findings are robust to reference price reduction rates and to sample stratification. Also, the degree of loss aversion among both nondisabled and disabled households attenuates with age and marital status. Findings provide new evidence of diminished cognitive bias and more rational economic decision-making among the physically disabled.

Future research could seek to further corroborate and explore the drivers of enhanced economic rationality on the part of the disabled. To that end, experimental approaches often utilized to assess cognitive bias (and, specifically, loss aversion) could be employed to provide improved understanding of (ir)rational behavior among nondisabled and disabled groups. Also, a limitation of our current study owes to the use of nondisabled tenants in public housing as our control group. These older and low-income households are not representative of the general nondisabled population. Examining the loss aversion behavior of disabled population using a representative control group in an experimental setting may thus be the next step in further understanding different irrational behavior patterns among the disabled. In that context, future research could explore the psychological and economic factors leading to diminished loss aversion on the part of the physically disabled.

APPENDIX A

TABLE A1
Price Reduction Algorithms by Sales Programs

Sales Program	**Dates**	**Characteristics Determining the Reduction Rate**	**Formula for Determining the Marginal Contribution of Each Characteristic to the Total Reduction Rate (%)**
1	February 23, 1999 to April 8, 2000	Number of persons in household and seniority in public housing	Up to $100 \times \frac{3{,}000\ (\text{NIS}) \times 6 \times 25}{\text{Value (NIS)}}$
		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)[a]
		Couple with or without children living in Type A-B regions	(20,000 NIS + 0.30 × (Value − ((1) + 20,000))) × (100/Value)[a]
		Single living in Type C regions	(5,000 NIS + 0.25 × (Value − ((1) + 5,000))) × (100/Value)[a]
		Couple with or without children living in Type C regions	(10,000 NIS + 0.25 × (Value − ((1) + 10,000))) × (100/Value)[a]
2	April 9, 2000 to September 14, 2003	Seniority in the unit Tenants living in Type A-B-C regions	3.0% × seniority until 1/1/2000 + 1.5% × 2 for 2001 − 2002 + 1.0% for 2003
		Seniority in the unit (years) 100% disabled confined to a wheelchair living in Type A-B-C regions	4.0% ×years _of residence until 1/1/2000 + 1.5% × 2 for 2001 − 2002 + 1.0% for 2003
3	September 15, 2003 to September 14, 2003	Seniority in the unit (years) Tenants living in Type A-B regions	3.0%−2.0% × seniority until 1/1/2000 + 1.5% × 2 for 2001 − 2002 + 1.0% × 2 for 2003 − 2004

TABLE A1
continued

Sales Program	Dates	Characteristics Determining the Reduction Rate	Formula for Determining the Marginal Contribution of Each Characteristic to the Total Reduction Rate (%)
		Seniority in the unit (years)	1.0% × seniority
		Tenants living in Type C regions	
		Seniority in the unit (years)	4.0% × seniority until 1/1/2000 + 1.5% × 2 for 2001–2002 + 1.0% × 2 for 2003–2004
		100% disabled confined to a wheelchair living in Type A-B-C regions	
4	January 1, 2005 to 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
5	August 11, 2005 to 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 to 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%

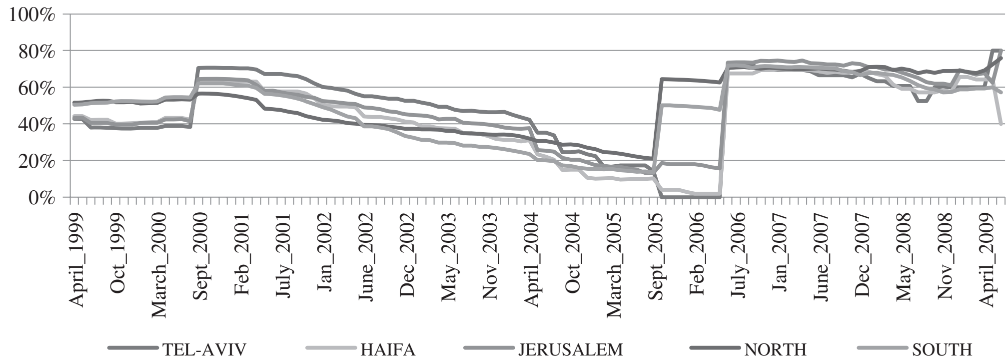
Notes: The table displays the maximum price reduction rates obtained via the price reduction algorithms and stratified by programs and sociodemographic criteria. The sources of these algorithms are memos of the ministry of housing and construction, which apply government's decisions via public housing corporations. Once the unit is purchased, the reduction rate becomes permanent if the purchased unit is not sold within 5 years, or is sold to improve dwelling conditions. 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. A 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 three period). The programs include ceilings of the lowest between 75% and 300,000 NIS (program 1), 90%–95% (program 2—nondisabled 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

[a](1) is equal to $3,000$ (NIS) $\times 6 \times 25$. Also, defining $A = 5{,}000$; 10,000; 20,000 NIS, and $B = 0.25$; 0.30, for 100% disabled tenants confined to a wheelchair the formula becomes $((2) + (A + B \times (\text{Value} - ((2) \times \text{Value} + A)))) \times (100/\text{Value})$. In calculating $B \times (\text{Value} - ((1) + A))$ or $B \times (\text{Value} - ((2) \times \text{Value} + A))$, Value equals the appraised value of the unit if Value $\leq 400{,}000$ NIS and 400,000 NIS if Value $> 400{,}000$ NIS.

APPENDIX B: REDUCTION RATES BY TENANT, LOCATIONAL, AND BUILDING CHARACTERISTICS

FIGURE B1

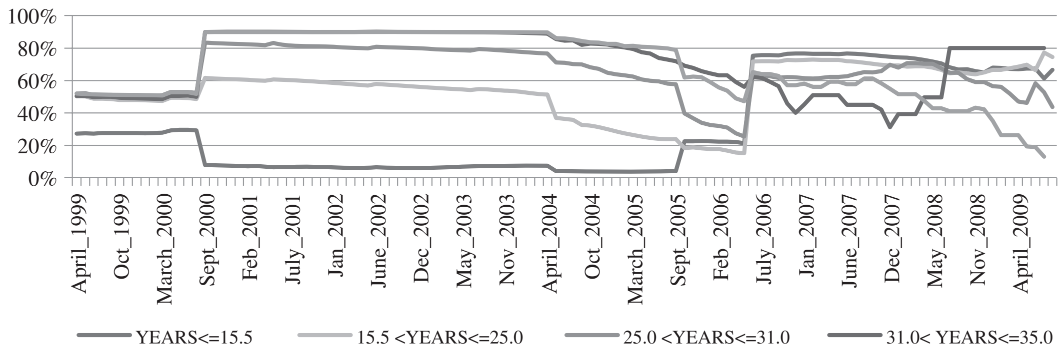
Reduction Rates by Location



Notes: Tel-Aviv, Haifa, and Jerusalem are the three largest cities in Israel.

FIGURE B2

Reduction Rate Schemes by Duration of Residence in Public Housing

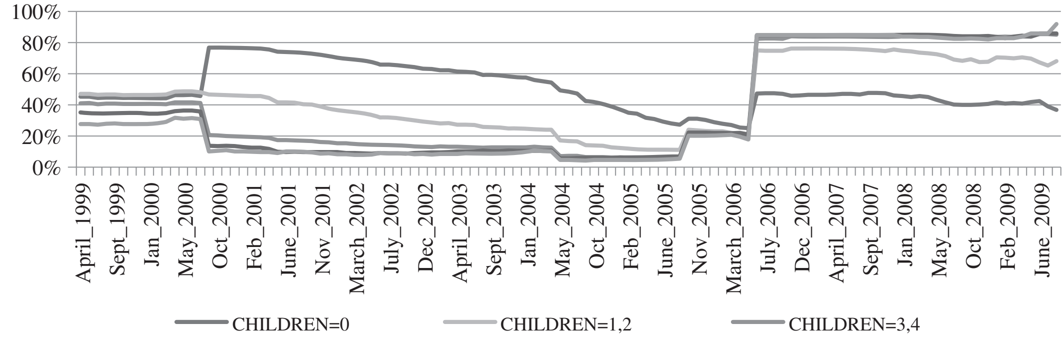


Notes: Duration in the public housing project is stratified by sample quintiles.

Quintiles (%)	Duration (Years)
20.0	15.5
40.0	25.0
60.0	31.0
80.0	35.0

FIGURE B3

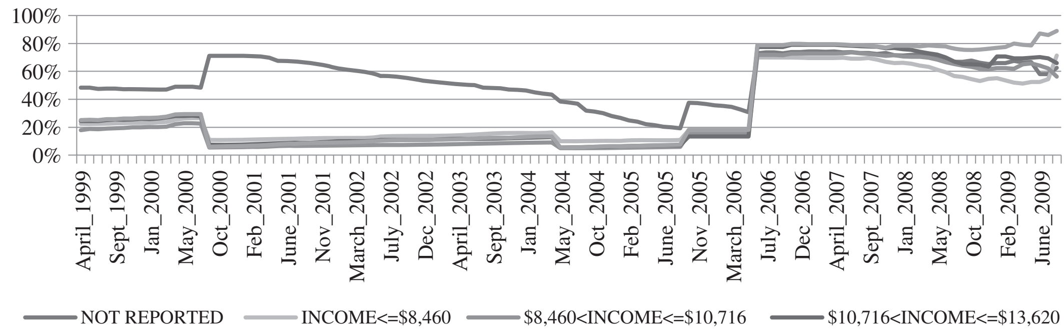
Reduction Rates by Number of Children in Household



Notes: This figure only refers to children under 21 years old.

FIGURE B4

Reduction Rates by Household Income

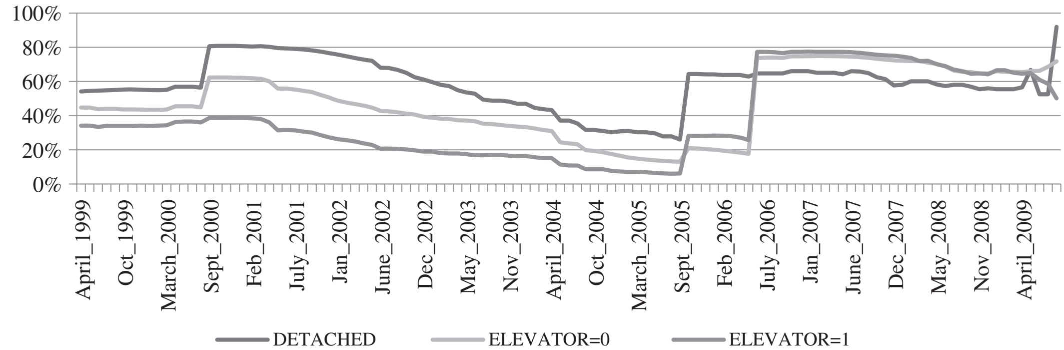


Notes: Of 6,852 households participating in the estimation, 1,002 reported their level of income. Reported levels of income are translated to US$ and stratified by sample quartiles.

Quartile (%)	Monthly NIS	Monthly US$ (=Monthly NIS/4)	Annual US$ (=Monthly US$ × 12)
25	$2,820	$705	$8,460
50	$3,572	$893	$10,716
75	$4,540	$1,135	$13,620

FIGURE B5

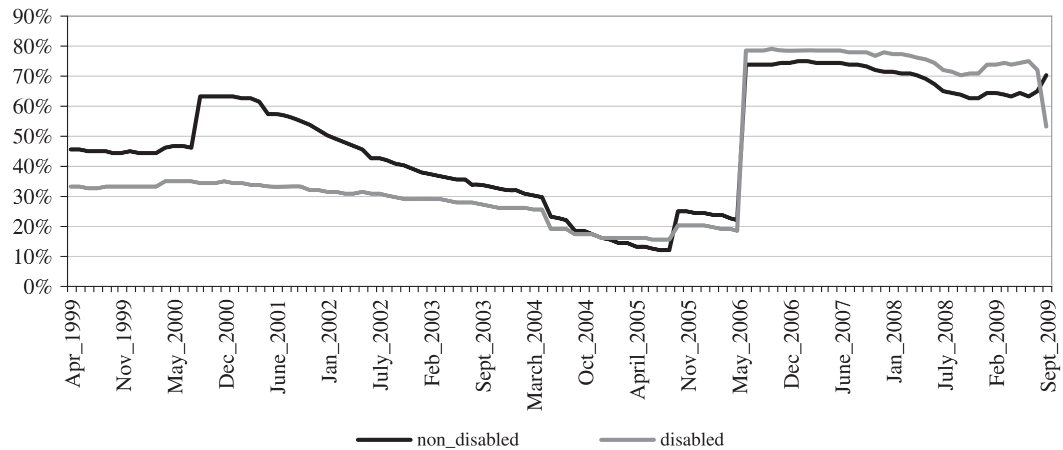
Reduction Rates by Type of Structure



Notes: Structure types include: detached units, condominiums in structures with an elevator, and condominiums in structures without an elevator.

FIGURE B6

Reduction Rates by Disability Status



Notes: Disability status includes: nondisabled and disabled tenants.

APPENDIX C

TABLE C1
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	5,520.99	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

TABLE D1
Auxiliary Regressions for Generating Permanent Income

Variables	Equation (3)	Equation (2)
$DURATION_i$	9.64***	−0.03***
	(3.48)	(6.27×10^{-4})
$CHILDREN_i$	—	0.16***
	—	(4.91×10^{-3})
$DIVORCED_i$	−3,799.00***	0.62***
	(70.20)	(0.02)
$WIDOW_i$	−3,081.00***	0.42***
	(71.78)	(0.02)
$SINGLE\_PARENT_i$	−1,912.00***	0.61***
	(71.27)	(0.02)
$SINGLE_i$	−5,177.00***	0.13***
	(66.60)	(0.02)
D_i	12.90***	0.01***
	(0.93)	(2.28×10^{-4})
$WHEELCHAIR_i$	−880.10***	−0.91***
	(231.7)	(0.06)
$HEAD\_AGE_i$	−11.93***	0.02***
	(1.91)	(5.12×10^{-4})
$NORTH_i$	230.30**	0.21***
	(95.26)	(0.03)
$GUSH\_DAN_i$	700.00***	−0.36***
	(112.20)	(0.03)
$SOUTH_i$	3.96	0.25***
	(94.71)	(0.03)
$JERUSALEM_i$	1,090.00***	−0.269***
	(123.70)	(0.03)
$CENTER_i$	617.50***	−0.05
	(108.70)	(0.03)
$KRAYOT_i$	813.20	-8.86×10^{-3}
	(698.5)	(0.21)
$SHARON_i$	570.70***	−0.26***
	(111.80)	(0.03)
TEL_AVIV_i	658.10***	−0.30***
	(183.20)	(0.05)
$AREA_i$	—	-2.53×10^{-4}***
	—	(6.53×10^{-5})
$ROOMS_i$	—	−0.16***
	—	(0.01)
$FLOOR_i$	—	0.039***
	—	(4.90×10^{-3})
STORIES	—	0.02***
	—	(4.99×10^{-3})
$ELEVATOR_i$	—	0.02
	—	(0.03)
$SHELTERS_i$	—	0.11***
	—	(9.43×10^{-3})
$ENTRANCES_i$	—	0.02***
	—	(3.18×10^{-3})
$STRUCT\_AGE_i$	—	0.02***
	—	(4.00×10^{-4})
$STRUCT\_PER_i$	—	-2.22×10^{-3}***
	—	(2.36×10^{-4})
Inverse-mills ratio	—	1,164.00***
	—	(135.90)
Constant	11,216.00***	−0.98***
	(178.90)	(0.06)
Observations	58,665	58,665
Censored obs.	22,840	22,840
Chi-square statistics	8822	8822

Notes: The table displays the auxiliary regression from which the permanent income has been generated for each household in the sample. The dependent variable in the selection equation is the probability to report the level of income. Numbers in parentheses are standard errors.

**Significant at 5%; ***significant at 1%.

APPENDIX E: LOSS-GAIN RATIO AND DEMOGRAPHICS

In order to examine the effect of the qualitative *MARRIED* term, we split the sample into married and unmarried groups and reestimate Equations (1)–(3) separately for each of those groups. To examine the sensitivity of the loss-gain ratio to *HEAD_AGE*, we extend Equation (1) to include the following interaction terms:

$$\text{(1b)} \quad h(t) = h_{02}(t) \exp[\theta_0 + \theta_1 REF_{i,t} \times NEG_{i,t} + \theta_2 REF_{i,t} \times POS_{i,t} + \theta_3 REF_{i,t} \times (1 - NEG_{i,t}) \times (1 - POS_{i,t}) + \theta_4 |RED_{i,t} - REF_{i,t}| \times NEG_{i,t} + \theta_5 |RED_{i,t} - REF_{i,t}| \times POS_{i,t} + CONTROL \times \overline{\theta}_6^T + \psi_{2,i,t}],$$

where

$$\text{(1b.0)} \quad \theta_0 = \omega_6 \times D_i + \omega_{12} \times HEAD\_AGE_i + \omega_{18} D_i \times HEAD\_AGE_i,$$

$$\text{(1b.1)} \quad \theta_1 = \omega_1 + \omega_7 \times D_i + \omega_{13} \times HEAD\_AGE_i + \omega_{19} D_i \times HEAD\_AGE_i,$$

$$\text{(1b.2)} \quad \theta_2 = \omega_2 + \omega_8 \times D_i + \omega_{14} \times HEAD\_AGE_i + \omega_{20} D_i \times HEAD\_AGE_i,$$

$$\text{(1b.3)} \quad \theta_3 = \omega_3 + \omega_9 \times D_i + \omega_{15} \times HEAD\_AGE_i + \omega_{21} D_i \times HEAD\_AGE_i,$$

(1b.4) $$\theta_4 = \omega_4 + \omega_{10} \times D_i + \omega_{16} \times HEAD\_AGE_i + \omega_{22} D_i \times HEAD\_AGE_i,$$

(1b.5) $$\theta_5 = \omega_5 + \omega_{11} \times D_i + \omega_{17} \times HEAD\_AGE_i + \omega_{23} D_i \times HEAD\_AGE_i,$$

(1b.6) $$\overline{\theta}_6 = \left(\omega_{24}, \omega_{25}, \ldots, \omega_{33}\right).$$

Note that substituting Equations (1b.0)–(1b.6) into Equation (1b) allows for interaction of $HEAD\_AGE_i$ with the disability index, D_i. The $\omega_1, \ldots, \omega_{33}$ are 33 estimated coefficients. The row vector $\overline{\theta}_6^T$ is the transpose of the column vector $\overline{\theta}_6$, $\psi_{2,i,t}$ is a random disturbance term and all other variables are as described following Equation (1).

Thus, for our variables of focus—$REF_{i,t} \times Sign_{i,t}$ and $|RED_{i,t} - REF_{i,t}| \times Sign_{i,t}$ $[Sign_{i,t} = \{NEG_{i,t}, POS_{i,t}, (1 - POS_{i,t})(1 - NEG_{i,t})\}]$—Equation (1b) together with Equations (1b.0)–(1b.6) generate three sets of interaction terms: D_i, $HEAD\_AGE_i$, and $D_i \times HEAD\_AGE_i$; hence, other than the matrix *CONTROL*, there are 20 variables with interaction terms included in Equation (1b).

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