Appendix to "Public Housing Units vs. Housing Vouchers: Accessibility, Local Public Goods, and Welfare"

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`http://home.ku.edu.tr/~ssarpca/web_appendix.pdf`

A.1 Robustness and Extensions

A.1.1 Utility Parameters and Tax Rates

The most desired property tax rates for the two household types are chosen to be slightly higher/lower than the U.S. average of 1.40%, and the utility parameters α_H and α_L are calibrated according to equation (8) in the paper. We conduct an additional analysis with alternative specifications for the levels of α_i's, which affect desired tax rates by about $\pm 20\%$ or more. Table A.1 reports representative results results from these alternative specifications along with the original specification given in the middle row of each panel. An inspection of the columns reporting the changes in overall welfare (AU) under two policies shows our findings are robust to such changes in property tax rates.

Table A.1: Welfare II - Property Tax Rates

	Public Housing				Vouchers			
$(\alpha_H, \alpha_L; \tau_H^*, \tau_L^*)$	S	U	P	**AU**	S	U	P	**AU**
(**.018**, .014; 1.52, 1.04)	-4.85	-5.18	81.74	**-0.34**	-2.93	-2.72	59.42	**1.03**
(**.021**, .014; 1.97, 1.04)	-5.64	-5.39	85.67	**-0.35**	-3.29	-3.31	59.01	**0.54**
(**.024**, .014; 2.54, 1.04)	-5.26	-5.20	82.04	**-0.25**	-3.01	-2.72	59.42	**0.97**
(.021, **.012**; 1.97, 0.84)	-4.89	-4.90	76.36	**-0.17**	-2.99	-2.73	59.50	**0.99**
(.021, **.014**; 1.97, 1.04)	-5.64	-5.39	85.67	**-0.35**	-3.29	-3.31	59.01	**0.54**
(.021, **.016**; 1.97, 1.26)	-5.20	-5.49	88.16	**-0.08**	-3.00	-2.78	59.23	**0.96**

A.1.2 Labor Supply

One of our findings is that households decrease their labor supply when provided with public housing units. In this section we provide representative results from additional analysis in which we vary: 1. The sizes of public housing units; 2. The location of the public housing units; 3. Utility (and tax rate) parameters. Table A.2 summarizes average working hours per week, comparing the labor supply of public housing residents and housing voucher recipients to labor supply of the households that live on the public housing location in benchmark equilibrium.[1] One row in each panel (+25%, 2-4.90, and (.014, .021), in bold) represents the original model for reference. Public housing recipients work less than voucher recipients (The only exception arises when public housing is built at the CBD and a public housing resident's travel cost becomes zero).

Table A.2: Average Weekly Labor Supply of Housing Aid Participants (hours/week)

	Benchmark	Public Housing	Housing Vouchers
Size			
-25%	41.2	35.6	42.0
0	41.2	37.3	42.0
+25%	**41.3**	**38.6**	**42.0**
+50%	41.3	40.6	42.0
+75%	41.3	42.3	42.0
Location			
0-4.47	40.7	42.5	42.0
2-4.90	40.9	41.1	42.0
4-6.00	**41.3**	**38.6**	**42.0**
6-7.48	41.7	37.2	42.0
$(\boldsymbol{\alpha_L}, \boldsymbol{\alpha_H})$			
(.012,.021)	41.3	39.1	41.7
(.014,.018)	41.3	39.0	41.7
(.014,.021)	**41.3**	**38.6**	**42.0**
(.014,.024)	41.3	38.9	41.7
(.016,.021)	41.3	38.8	41.7

[1] The band occupied by public housing hosted unskilled households in benchmark equilibrium; see Figure 1.

A.1.3 Vouchers for All Unskilled Households

Rationing of housing vouchers to a fraction of eligible households is consistent with the practices in the U.S. (Downs, 1991). The lottery specification in the paper has the additional benefit of keeping the program size the same as under public housing. An alternative implementation is to provide vouchers to every household below a certain income level. With just two income levels in the model, this means providing vouchers to all unskilled households, increasing the number of program participants from 9% to 60% of the population. Holding income tax rate constant decreases the voucher amount to $34 per household. The findings of this exercise given in Table A.3 are quite similar to those of the lottery specification in the paper.

Table A.3: Housing Vouchers II
(Every Unskilled Household Gets Vouchers)

Income Tax Rate: 0.57%		
	West	East
Average Monthly Rent (per Acre)	$2727	$2192
Property Tax Rate	1.97%	1.04%
School Quality	13.96	6.93
Distribution of Households Across Neighborhoods		
S	70%	30%
U	41%	59%
Neighborhood Population Breakdown		
S	53%	26%
U	47%	74%

A.1.4 Housing Industry

Our framework is based on Alonso's model (1964) which assumes that each household manages the construction of its house by itself. An alternative approach is Muth's model (1969) in which households derive utility from consuming housing space H, produced by competitive firms using Λ units of land and K units of capital with the production function:

$$H = AK^a\Lambda^{1-a} \tag{1}$$

for $a \in (0, 1)$ and $A > 0$. Then as land gets more expensive closer to the CBD, the share of capital to land in the construction of housing space increases, i.e., taller/multi-unit buildings are observed.

We incorporate this housing industry to our framework, and repeat the analysis presented so far in this paper. This change in the formulation does not alter our qualitative findings regarding welfare comparisons, while adding considerable complexity to the analysis. We solve the equilibrium without government intervention (benchmark), with public housing, and with housing vouchers. We calibrate the parameters of the housing production function so that *the ratio of housing space to land* is about 16 near the CBD and 1 near fringe in the benchmark model.[2]

[2]These can be interpreted as the number of floors of buildings, but one should also keep in mind that it is a

We initially locate the public housing units at 4 miles away from the CBD, keeping the ratio of housing space to land at the benchmark level at this distance (about 4). We set the public housing unit size same as the average unit in the same area in benchmark. We have also solved alternative models with: 1. The public housing unit size 25% smaller and 25% larger than the average unit in the same area in benchmark; 2. The ratio of housing space to land is 3 and 5; 3. The location of public housing units at 3 and 5 miles away from the CBD. We summarize results from this analysis in Table 7 below. The middle rows in top three panels (titled as "same," "4," "4 miles") represent the main public housing model, and the very bottom row in the table presents the welfare implications of the voucher model with housing industry.

An inspection of Table A.4 reveals that housing vouchers are preferable to public housing units in this extended model too. We also solve this extended model with alternative utility-tax parameters. Table A.5 presents the counterpart to Table A.1 with housing industry.

In the first and last rows of the table, where the utility parameters of the two types get close to each other, the overall welfare under public housing is slightly greater than that under vouchers. However, a closer inspection of the Table reveals that households that do not participate in the program still prefer housing vouchers to public housing units. The higher overall welfare results from the large difference from program participants' utility levels.

Table A.4: Models with Housing Industry I - Size, Share of Capital, and Location

	S	U	P	AU
Size				
-25%	-5.23	-4.67	70.39	-0.47
same	-5.13	-4.64	81.96	0.11
+25%	-5.06	-4.63	81.93	0.15
Housing Space/Land				
3	-6.01	-5.47	83.09	-0.67
4	-5.13	-4.64	81.96	0.11
5	-4.61	-4.13	77.99	0.44
Location				
3 miles	-5.08	-4.78	86.45	0.25
4 miles	-5.13	-4.64	81.96	0.11
5 miles	-5.04	-4.46	68.04	-0.39
Vouchers				
	-2.84	-3.34	56.22	0.60

continuous variable. The implied parameters for the production function are a=0.70 and A=0.00149. Given the change in tax base, we also recalibrate the parameters of the education production function to facilitate comparisons with the models in Sections 3 and 4 of the paper. Further details are available from the authors.

Table A.5: Models with Housing Industry II - Utility Parameters

	Public Housing				Vouchers			
$(\alpha_H, \alpha_L; \tau_H, \tau_L)$	S	U	P	AU	S	U	P	**AU**
(**.018**, .014; 1.52, 1.04)	-4.60	-3.29	79.97	**0.97**	-3.03	-2.94	56.16	**0.73**
(**.021**, .014; 1.97, 1.04)	-5.13	-4.64	81.96	**0.11**	-2.84	-3.34	56.22	**0.60**
(**.024**, .014; 2.54, 1.04)	-8.79	-17.81	46.27	**-9.94**	-3.12	-2.95	56.01	**0.65**
(.021, **.012**; 1.97, 0.84)	-3.79	-3.66	67.26	**0.54**	-2.49	-3.16	56.69	**0.87**
(.021, **.014**; 1.97, 1.04)	-5.13	-4.64	81.96	**0.11**	-2.84	-3.34	56.22	**0.60**
(.021, **.016**; 1.97, 1.26)	-5.17	-4.02	89.61	**0.75**	-2.96	-3.00	56.16	**0.72**

A.2 The Algorithm used for Solving the Benchmark Equilibrium

The following algorithm is based on the sequence of events described in the paper. Also see Figure A1 below. The school district j could be East or West. If we know the bid-rent curve of a household type in one district, we can draw the bid-rent curve for the same type in the other district as well, since identical households obtain the same level of utility regardless of where they live.

1. Define model parameters and discretize the space.

2. Equation 3 (and some algebra) suggests that bid-rent curve Ψ_1 of a household is steeper than that Ψ_2 of another if and only if for all r at which $\Psi_1(r,.) = \Psi_2(r,.)$, $\frac{\eta_1+\gamma+\delta}{\eta_1}\frac{\eta_2}{\eta_2+\gamma+\delta}\frac{(a+bW_1)Y_2(r)}{(a+bW_2)Y_1(r)} > 1$. Moreover, the household with a steeper bid-rent curve locates closer to the employment center. Check this ratio and determine the spatial order of households. In our paper, unskilled households have a steeper bid-rent curve and locate closer to the employment center.

3. Randomize the initial tax rate/quality of education package in each district.

4. Initialize fringe distance, r^*_{fj}. Find u^*_S by using equation 3 in the paper and the fact that at r^*_{fj}, the rent is the agricultural rent R_a. Use this information to calculate bid-rent and lot sizes for skilled households in both districts.

5. Initialize r^*_{SUj}. Calculate the rent at r^*_{SUj} by using the bid-rent function of skilled households. Then find u^*_U by using equation 3. Calculate bid-rent and lot sizes for unskilled households in both districts.

6. Determine the land area that skilled households outbid unskilled households. By using lot sizes, calculate the population of skilled households.

7. If it is larger (smaller) than the target value, go back to 5 and increase (decrease) r^*_{SUj}. If it equal to the target value, move on to the next step.

8. By using lot sizes, calculate the population of unskilled households. If it is larger (smaller) than the target value, go back to 4 and decrease (increase) r^*_{fj}. If it equal to the target value, move on to the next step.

9. Find majority winner property tax rates, tax bases, and quality of education in each school district.

10. Go back to step 3 and update tax rate/education package. Repeat until the current period tax rate/education packages are equal to those in the last period.

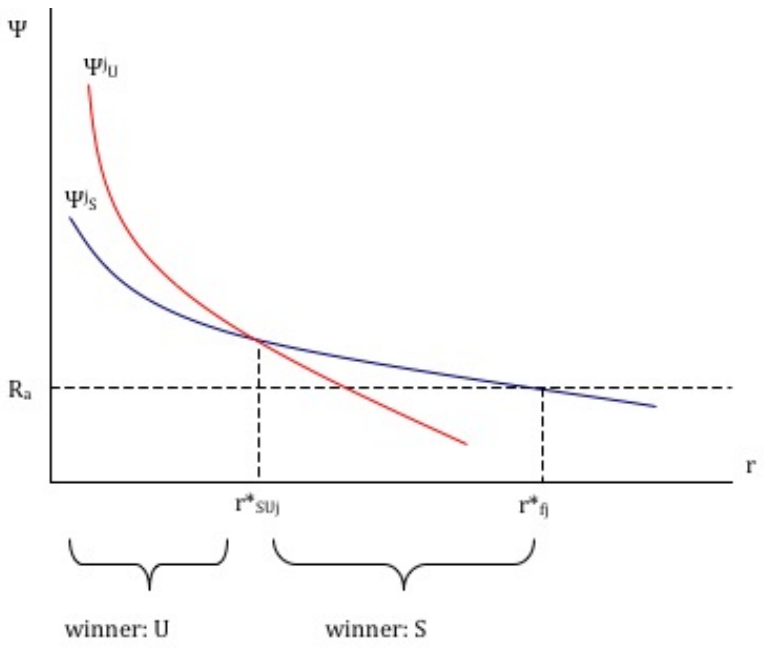

Figure A1