When education policy and housing policy interact: can policies correct for the externalities?

Yifan Gong, University of Western Ontario, Canada;

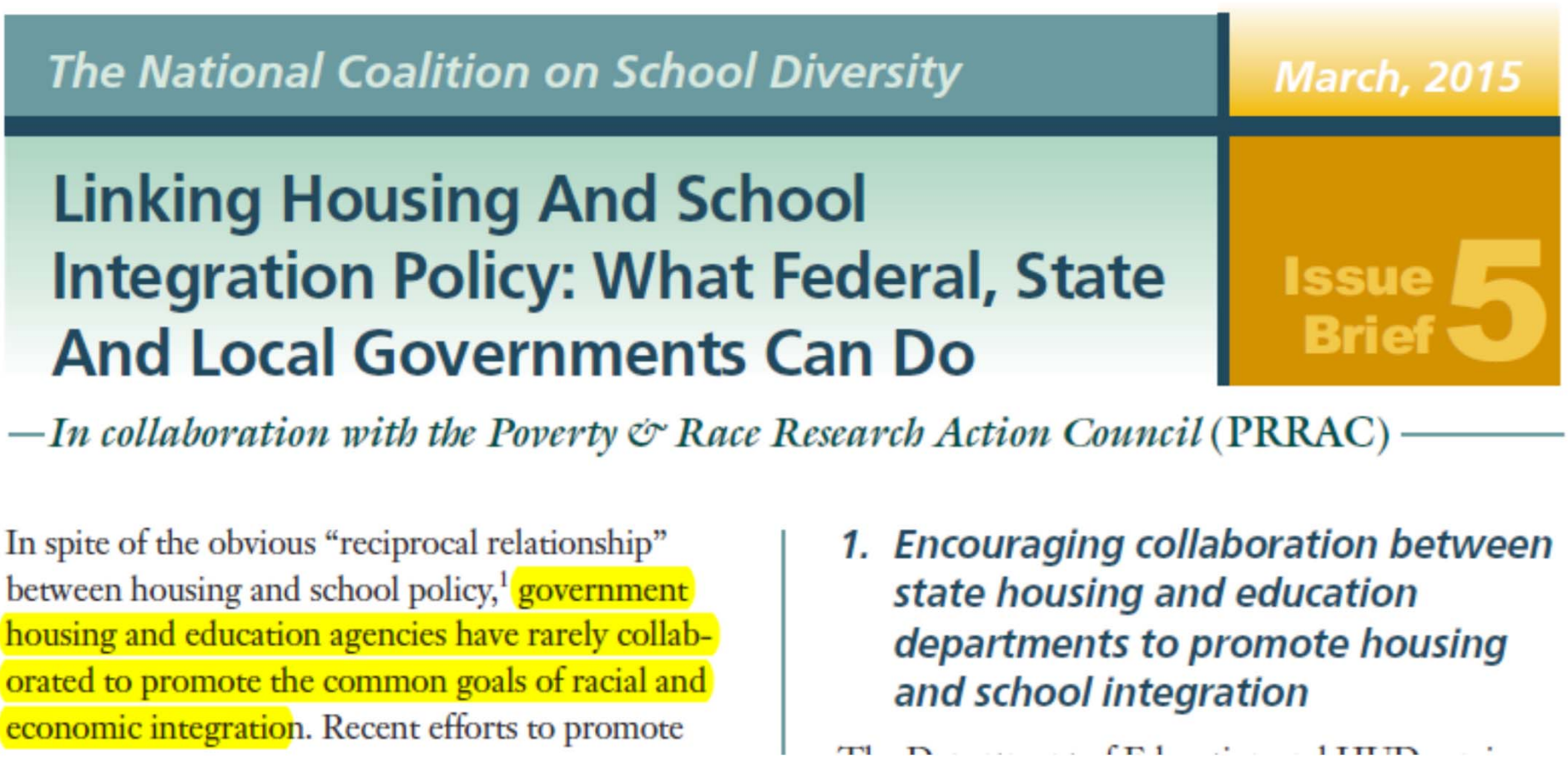
Charles Ka Yui Leung, City University of Hong Kong, Hong Kong

This version: July 2019

- **Thanks for the opportunity** to present
- This talk: *much simpler than* other papers you have heard...
- **Objective: Build a simple, credible model (consistent with several stylized facts), &**
- **Conduct Policy Analysis**
- *(What are the issues?) (next slide)*
- *(What are the facts?) (after next slide…)*

Big Picture Questions

- *(Primary, Secondary schools often provided locally, e.g. traffic concerns…)*
- Should local government fund the education? Or we should pool resources across different jurisdictions?
- Should local government provide for public housing?
- Does an “integrated” education and housing policy package help?



The National Coalition on School Diversity

March, 2015

Linking Housing And School Integration Policy: What Federal, State And Local Governments Can Do

Issue Brief 5

—*In collaboration with the Poverty & Race Research Action Council* (PRRAC)

In spite of the obvious "reciprocal relationship" between housing and school policy,[1] government housing and education agencies have rarely collaborated to promote the common goals of racial and economic integration. Recent efforts to promote

1. *Encouraging collaboration between state housing and education departments to promote housing and school integration*

- (other social scientists and activists…)

Local Public Finance (LPF) in USA

- Hanushek and Yilmaz (2011, p.583): "…The ***reliance on the local tax for a large portion of school funding*** implies that the government grant system has an important effect on both locational decisions and educational outcomes… **Education in the United States is provided by local school districts that operate with considerable autonomy.** Funding is provided by a combination of local, state, and federal revenues with the level of spending and the performance of schools varying significantly across school districts…"

Local Public Finance (LPF) in USA (2)

- Chetty and Hendren (2018, p.1159~1160) analyze the admin. data (19 million U.S. citizens), conclude that

"...*Neighborhoods affect children's long-term outcomes through childhood exposure effects*: every extra year a child spends growing up in an area where permanent residents' incomes are higher increases his or her income."

Stylized facts in urban econ…

FACTS: (Davidoff 2005; Hardman & Ioannides, 2004)

- ***Negative*** relationship between **income level** and **fertility** choice (US Census Data; next)
- ***PARTIAL*** income sorting **WITHIN** and **ACROSS** communities. (# type > # communities)
- Theoretical: (De Bartolome & Ross 2003, 2007; Brueckner, Thisse & Zenou 1999; Tivadar 2010)
- **Parental provision**-dependent ***education quality*** (Maurin 2002; Goux & Maurin 2005; Gertler et al 2004)

Table 1a Educational Attainment, Annual Income and Fertility Rate

Level of Education	Male Income (in $)	Female income (in $)	Income of Pseudo Household (in $)	Female Fertility Rate	Average Income ($) across Groups	Average Fer. Rate across Groups
Less than 9th grade	26,604	19,588	46,192	2.521	51,432	2.521
9th to 12th grade	33,194	23,478	56,672			
High school graduate	43,140	32,227	75,367	1.954	87,479	1.918
Some college	52,580	36,553	89,133	1.892		
Associate degree	55,631	42,307	97,938	1.869		
Bachelors degree	92,815	62,198	155,013	1.682	155,013	1.652
Graduate or professional degree				1.597		
Total	62,445	44,857	107,302	1.888	N/A	N/A

Table 7 Comparison of Hanushek-Yilmaz series

		Hanushek-Yilmaz (2007)	Hanushek, Sarpca and Yilmaz (2011)	Leung, Sarpca and Yilmaz (2012)	Hanushek-Yilmaz (2013)	This paper
Calibration Target Mid-sized U.S. City		Around 1997	Around 2005	Around 2005	Around 1997	Around 2010
Classification of Models	# of school Districts	2	2	2	3	2
	# of types of Agents	4	4	2	4	3
	How are agents differ?	In wage rate and preference for education	In wage rate and preference for education	In wage rate and preference for education	In wage rate and preference for education	In the degree of altruism toward children
(Average) Welfare Change for Selected Policy Experiments Considered						
School Consolidation		All agents (-)	N.A.	N.A.	All agents (- -)	N.A.
School Finance Consolidation		N.A.	All agents (- -)	N.A.	All agents (-)	All agents (+)
Private Schools		N.A.	All agents (+)	N.A.	N.A.	N.A.
Public Housing		N.A.	N.A.	Participant (+ +) Non-participant (- -) Average (-)	N.A.	Participant (+ +) Non-participant (-) Average (-)
Housing Vouchers		N.A.	N.A.	Participant (+) Non-participant (-) Average (+)	N.A.	Participant (+ +) Non-participant (-) Average (-)
School Finance Consolidation + Public Housing		N.A.	N.A.	N.A.	N.A.	Participant (+ +) Non-participant (+) Average (+)
School Finance Consolidation + Housing Voucher		N.A.	N.A.	N.A.	N.A.	Participant (+ +) Non-participant (-) Average (+)

- This paper: static general equilibrium model
- ***WHY static?***

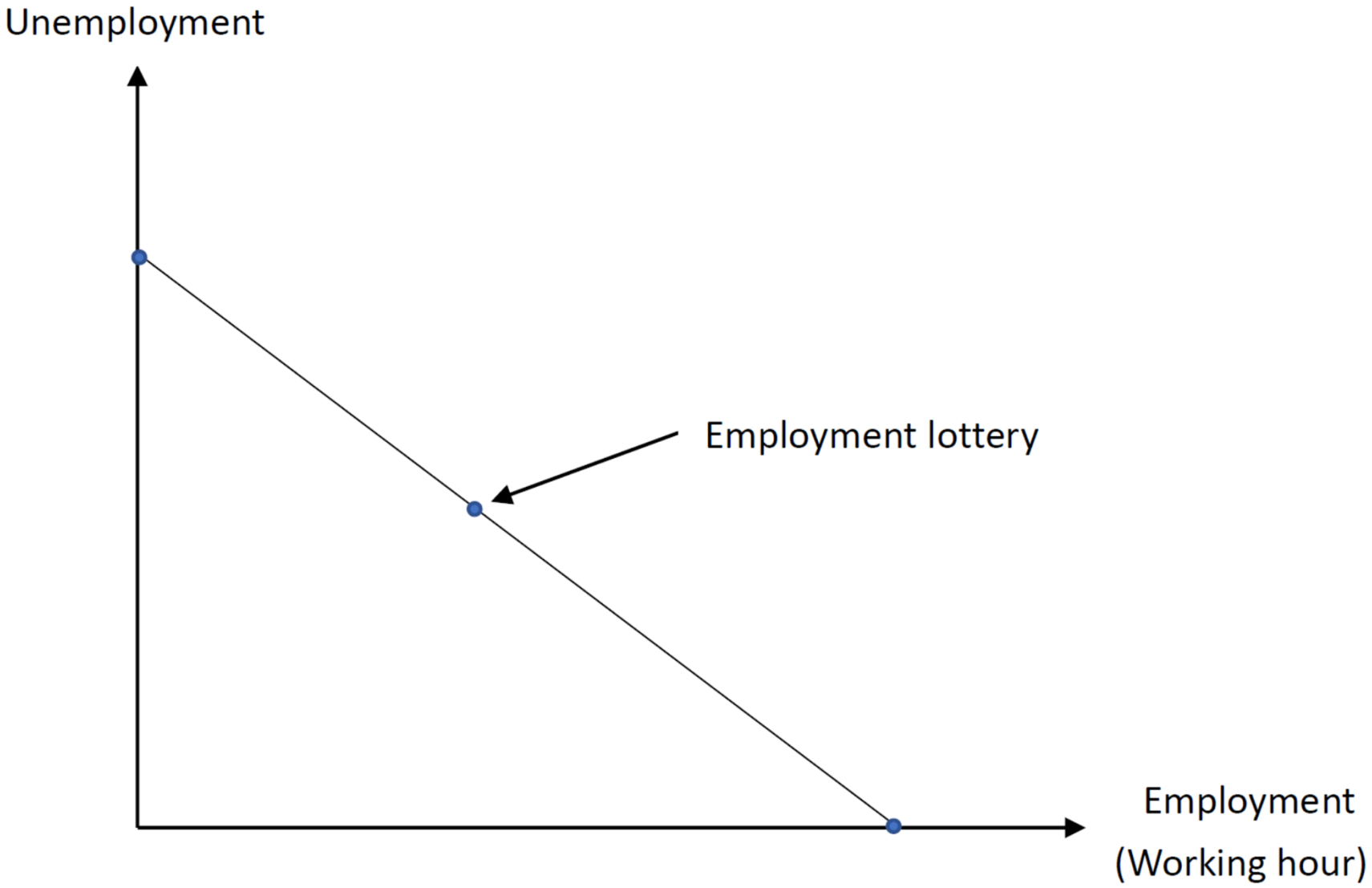
⇒***We focus on spatial sorting and non-convexity arises (next slide)***

⇒***We also consider majority voting (an important feature for U.S.; maybe other places as well)***

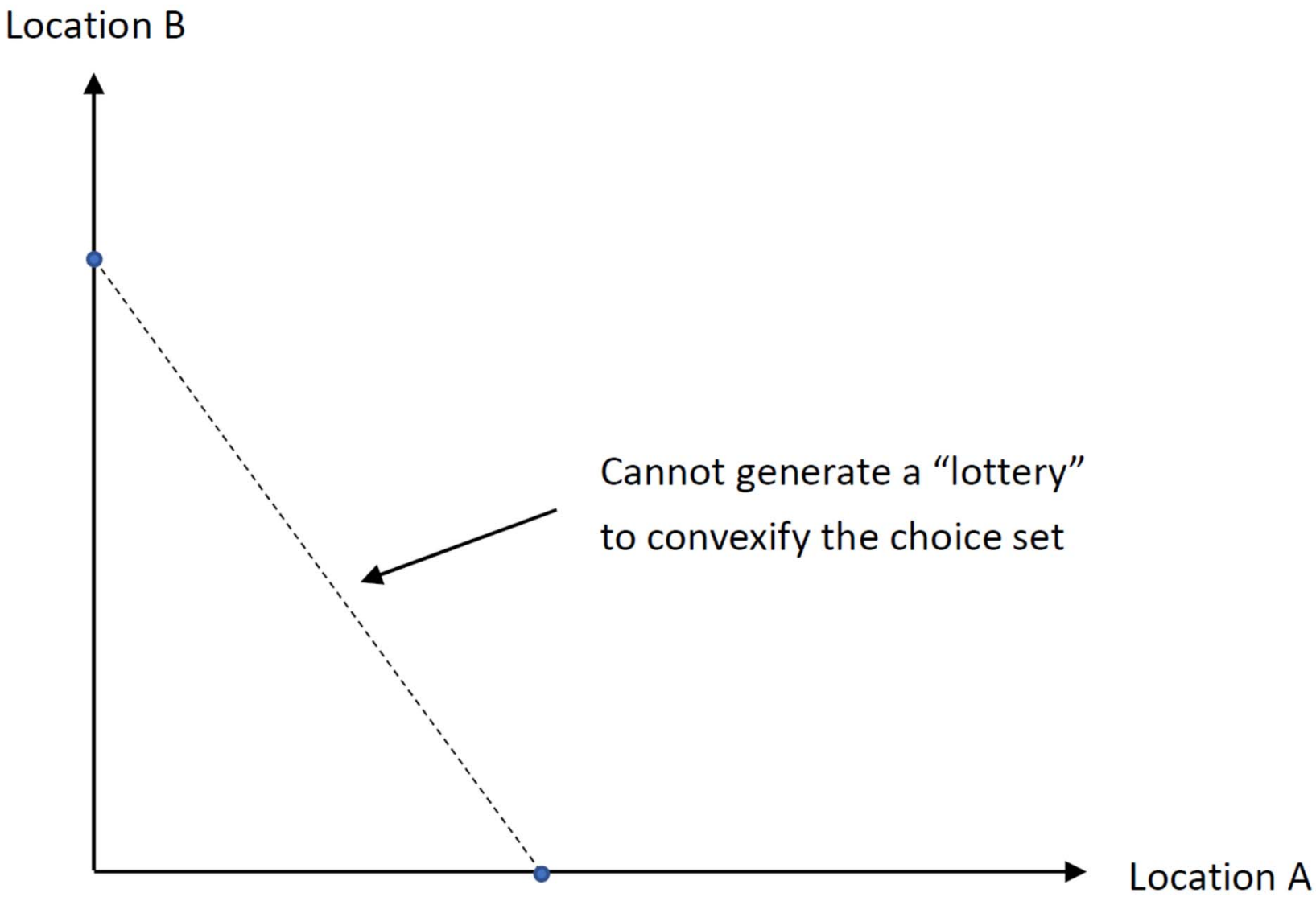
⇒***"Dynamic Voting" is very difficult.***

⇒Nonetheless, we will show "some favor" of dynamics (Short Run vs Long Run).

Hansen-Rogerson soln for unemployment



Unfortunately, in spatial econ…



This paper: a generalization of Hanushek-Yilmaz model (2007)

- Combine *Tiebout* ("vote by foot") and *Alonso* (land use within a community)
- (*ex ante identical* communities; whereas DBR: downtown-suburb: ex ante hetero.)
- **Monocentric city** model with **multi-districts** and **heterogeneous agents**
- income sorting is **endogenous** (*result: PARTIAL*)
- Allow fertility rate to be **endogenous**

This paper: a generalization of Hanushek-Yilmaz model (2007)

Trade-off between

- 1) *Parents' Well-being or Offspring's Quality*
- 2) *Quality or Quantity of offspring* (i.e. more spending per child or more children)
- 3) *Higher Income or More Children* (having more children means less time for work, hence less income)

WHY endogenous? (Fernandez-Rogerson)

- Imagine: originally 2 identical communities/ jurisdictions /districts (E & W) (local public finance)
- Now move an educated/higher wage household from E to W.
- W: proportion of edu

$\Rightarrow$ (tax-base effect & peer group effect)"Quality of Community", quality of edu

$\Rightarrow$ attract even more edu households to come

WHY endogenous? (*new here*!)

- Imagine: originally 2 communities/ jurisdictions /districts (E & W). E has a higher proportion of less edu/less skilled households; Each household restricted to have same # offsprings
- Now allow number of offspring to be chosen by parents.
- (under some parametrization) more edu households want smaller families.

$\Rightarrow$ W has less pupils

$\Rightarrow$ Expenditure per student in W

$\Rightarrow$ W becomes more attractive to more edu households

$\Rightarrow$ (opposite happens in E)

Model Setting

- Single-CBD city with two ex-ante symmetric districts (W&E)
- 3 types of households (***NH, HA, BA***) (differ in wage and preference for offspring's quality)
- All lands rent out via auction (Participants: ALL Households; Agricultural Use)
- *NH*: Not High-school graduates
- *HA*: High-School
- *BA*: Bachelor degree or above

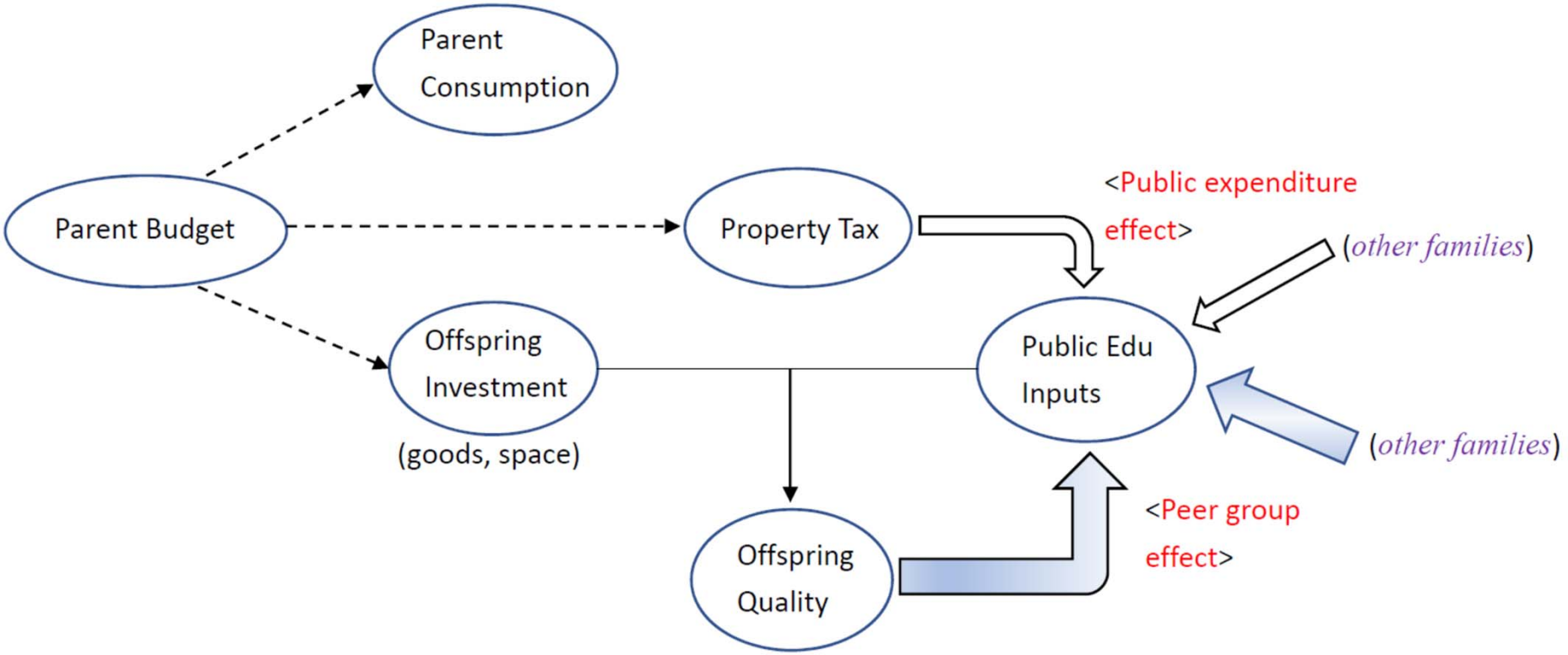
Model Setting (continued)

- Each district finances its own school by property tax revenues ***(local public finance)***
- Property tax rate determined by **majority voting**
- ***School quality*** is a function of

(1) per child ***funding***; (2) its ***peer*** quality (which depends on parental provision)

- (Parents) Positive commuting cost (time and pecuniary)

Family Budget Allocation



Utility Function

$$U\left(S_p, Z_p, l, S_o, Z_o, n_o\right) = (W)^{k_p}(\Omega_o^j)^{k_o} n_o g(n_o)$$

where $W = S_p^{\alpha_p} Z_p^{\beta_p} l^{\eta}$, $\Omega_o^j \equiv q_j^{\gamma} S_o^{\alpha_o} Z_o^{\beta_o}$, $g(n_o) \equiv g n_o^{-\epsilon}$.

Budget Constrant:

$$Y(r) = wl(r) + wC(n_o) + (S_p(r) + n_o(r)S_o(r))(1+\tau_j)R_j(r) + Z_p(r) + n_o(r)Z_o(r)$$

where $Y(r) = 24w - (a + bw)r,\ C(n_o) = cn_o$.

Notice that the quality of offspring, Ω_o,

depends on the offspring's *living condition* (which in turn depends on

the consumption Z_o and residential space S_o) and their *education quality* q.

Special Case

IF $\alpha_o = \beta_o = c = 0$, $g = n_o = 1$

$\Rightarrow S_o = Z_o = 0$

$\Rightarrow$ (appropriate re-labeling) reduce to Hanushek-Yilmaz (2007)

Land-Bidding, more formally…

For a Type $i \in \{NH, HA, BA\}$ household which lives in district $j \in \{W, E\}$, the maximization problem is

$$\psi_i(r, \overline{u}_i, q_j, \tau_j) = \max_{S_p, S_o, Z_p, l, Z_o, n_o} \left\{ \frac{Y_i(r) - Z_p - n_o Z_o - w_i l - w_i c n_o}{(1+\tau_j)(S_p + n_o S_o)} | U_i(.) = \overline{u}_i \right\} \tag{1}$$

Combine with the facts that $\alpha_p + \beta_p + \eta = 1$, $\gamma + \alpha_o + \beta_o = 1$ and $k_p^i + k_o^i = 1$, we obtain the *bid-rent function*

$$\psi_i(r, \overline{u}_i, q_j, \tau_j) = \frac{1}{1+\tau_j} \left\{ \frac{K_i q_j^{\gamma k_o^i} Y_i(r)^{k_T^i}}{\overline{u}_i} \right\}^{\frac{1}{k_S^i}} \tag{2}$$

Land-Bidding (continued)

and the *bid-max lot size* function

$$\begin{aligned} S_i(r, \overline{u}_i, q_j, \tau_j) &= S_p^i(r, \overline{u}_i, q_j, \tau_j) + n_o S_o^i(r, \overline{u}_i, q_j, \tau_j) \\ &= \frac{Y_i(r)}{\psi_i(r, \overline{u}_i, q_j, \tau_j)} \frac{k_S^i}{k_T^i} \frac{1}{1+\tau_j} \end{aligned} \tag{3}$$

where

$$K_i = \frac{g^{k_o^i} (\beta_p k_p^i)^{\beta_p k_p^i} (\beta_o k_o^i)^{\beta_o k_o^i} (\eta k_p^i)^{\eta k_p^i} (\alpha_p k_p^i)^{\alpha_p k_p^i} (\alpha_o k_o^i)^{\alpha_o k_o^i} (k_n^i)^{k_n^i}}{(k_T^i)^{k_T^i} w_i^{k_p^i \eta + k_n^i} c^{k_n^i}},$$

$$k_T^i = 2 - k_o^i - \epsilon,\ k_S^i = \alpha_p k_p^i + \alpha_o k_o^i,\ k_n^i = 1 - \epsilon - k_o^i(1-\gamma).$$

Lemma: In each neighborhood, the household with better educated adults live further from the CBD.

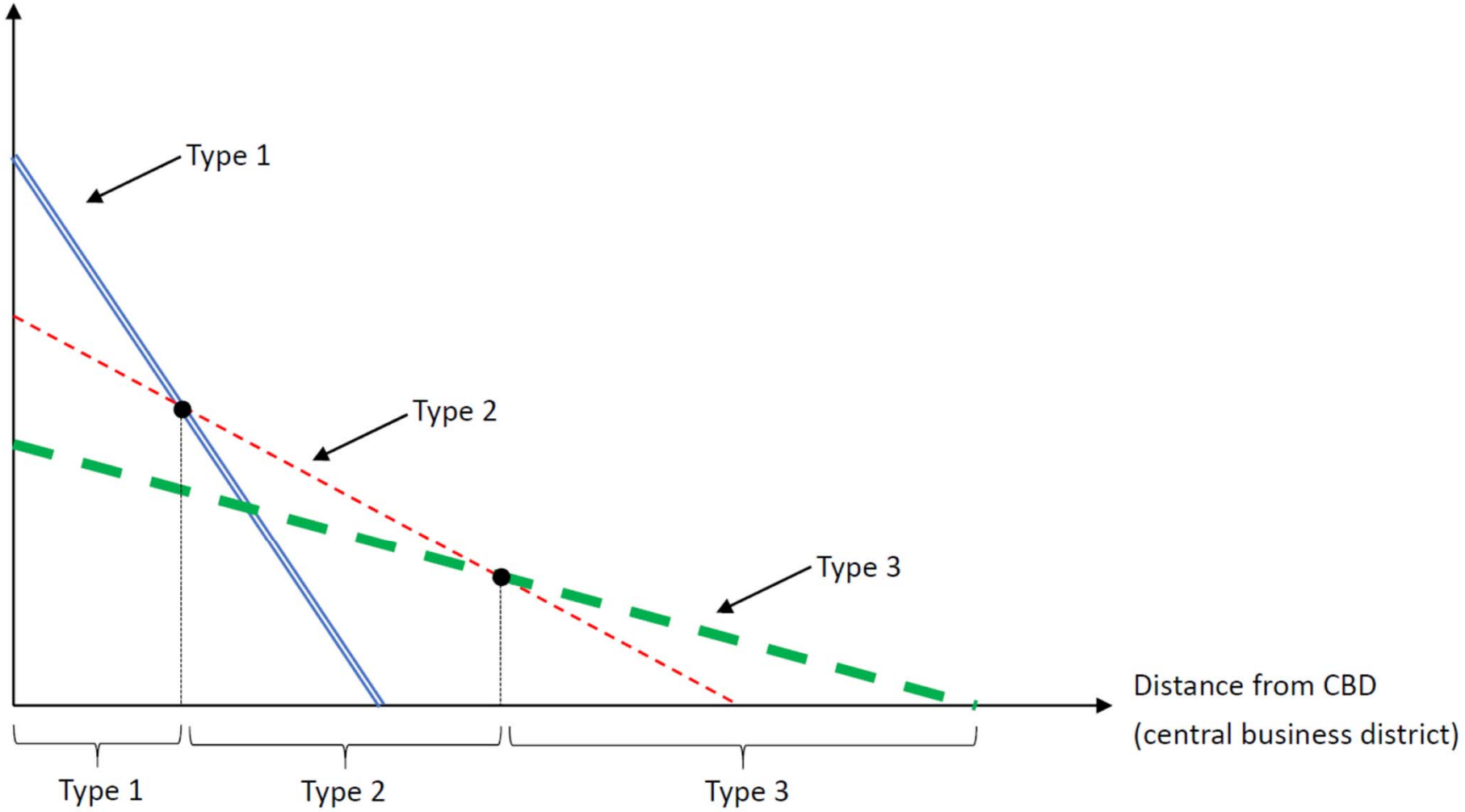
(intuition)

(***income effect***): live further away from CBD; bigger houses

(***substitution effect***); live closer to CBD; commute less

=> (this model) **income effect dominates**

Land bidding by different types of agents



Let $L(r)$ represent the land density at distance r.

Land market clear at each spot $\Rightarrow L(r) = S_i(r, u_i^\star, q_j, \tau_j) m_i^j(r, u_i^\star, q_j, \tau_j)$,

where $m_i^j(r, u_i^\star, q_j, \tau_j)$ is the equilibrium density function of household number in district j assuming distance r is occupied by type i household, and $u_i^\star$ is the equilibrium utility of type i household.

Every agent has a residing place $\Rightarrow$

$$\int_0^\infty m_i^W(r, u_i^\star, q_W, \tau_W) I[t_W^\star(r) = i] dr + \int_0^\infty m_i^E(r, u_i^\star, q_E, \tau_E) I[t_E^\star(r) = i] dr = \overline{N}_i \tag{4}$$

where $I[.]$ is an indicator function that takes the value 1 when the condition in brackets is satisfied and 0 otherwise.

It is easy to verify

$$m^j(r) = \sum_{i \in \{NH, HA, BA\}} m_i^j(r, u_i^\star, q_j, \tau_j) I[t_W^\star(r) = i]$$

The total population in this economy consists of the population of adults and the population of children, and the latter is endogenously determined.

Let $n_o^{ij}(r)$ to represent the fertility choice of type i parent in district j, located r miles from the CBD. The solution of (1) suggests that

$n_o^{ij}(r) = n_o^i(r) = \frac{k_n^i}{w_i c k_T^i} Y_i(r)$, which is independent of district j.

Therefore, the offspring population located r miles from the CBD and in district j is

$$m_o^j(r) = \sum_{i \in \{NH, HA, BA\}} n_o^i(r) m_i^j(r, u_i^\star, q_j, \tau_j) I[t_j^\star(r) = i].$$

Proposition 2 *Other things being equal, parents who care more about their offspring's quality bear fewer children.*

$$\frac{\partial n_o^i(r)}{\partial k_o^i} < 0$$

The budget constraint of the local government in jurisdiction j :

$$X_j N_o^j = \tau_j \int_0^{R_{jf}^\star} R_j(r) L(r) dr \tag{5}$$

where $N_o^j = \sum_{i \in \{NH, HA, BA\}} N_{oi}^j$ is the total population of the children in jurisdiction j, X_j is per student expenditure in district j, τ_j is the property tax rate.

Quality of Education in district j,

$q_j = X_j \Pi_j$,

where Π_j = peer group effect.

Assume: peer effect depends on the *average quality* *of all the students in the community.*

$$\Pi_j = c_1 + c_2 \exp(\overline{\Omega_o^j}),\ c_1, c_2 > 0 \tag{6}$$

$$\text{where } \overline{\Omega_o^j} = \frac{\sum_{i \in \{NH, HA, BA\}} \int_0^\infty \Omega_{oi}^j(r) n_o^i(r) m_i^j(r, u_i^\star, q_j, \tau_j) I[t_j^\star(r) = i] dr}{N_o^j}$$

$$\text{where } \Omega_{oi}^j(r) = q_j^\gamma S_o^{\alpha_o} Z_o^{\beta_o} = \left(\frac{k_o^i w_i c}{k_n^i}\right)^{\alpha_o + \beta_o} \frac{\alpha_o^{\alpha_o} \beta_o^{\beta_o} q_j^\gamma}{(1+\tau_j)^{\alpha_o} [\psi_i(r, u_i^\star, q_j, \tau_j)]^{\alpha_o}}$$

Proposition 3 *In each neighborhood, better educated adults produce offspring with higher quality.*

- Notice that there are different ways to model the "*peer group effect*".
- In Hanushek-Yilmaz series, it is the local composition that matters (ratio of skilled versus un-skilled).
- Liu et al. (2014) however find that for the efforts of student study, it is the **local average** that matters.
- (Liu et al. also show that for other activities, it is composition that matters…)

The parents are *myopic* when voting; they do not consider the implications of their votes on the population composition, land prices and the peer effects in both communities.

The preferred property tax rate:

$$\begin{aligned}
\max_{\tau_j^i} V_i(.) &= \frac{K_i q_j^{\gamma k_o^i} Y_i(r)^{k_T^i}}{\left[(1+\tau_j^i)R_j(r)\right]^{k_S^i}} \\
\text{subject to } q_j &= X_j \Pi_j \text{ and } X_j = \tau_j^i \overline{R_j}, \\
\text{where } \overline{R_j} &= \left[\int_0^{R_{jf}^\star} R_j(r)L(r)dr\right] / N_o^j. \qquad (7)
\end{aligned}$$

$$\Rightarrow \tau_j^i = \gamma k_o^i/(k_S^i - \gamma k_o^i) = \gamma k_o^i/(\alpha_p k_p^i + \alpha_o k_o^i - \gamma k_o^i).$$

Definition 1 *An equilibrium is a set of utility levels* $\{u^{\star}_{NH}, u^{\star}_{HA}, u^{\star}_{BA}\}$, *market rent curves* $\{R_W(r), R_E(r)\}$, *school quality and property tax rate pairs* $\{(q_W, \tau_W), (q_E, \tau_E)\}$, *household number/offspring population distribution functions* $\{(m^W(r), m^W_o(r)), (m^E(r), m^E_o(r))\}$ *and type functions* $\{t^{\star}_W(r), t^{\star}_E(r)\}$ *that show the equilibrium occupant of the location at distance* r *in jurisdiction* j *such that*

- *The households offer their bids according to equation (2). The land is sold through an auction and the winner of a particular location is the household offering the highest bid, given such bid is higher than the agricultural rent. Otherwise, the land is left for agricultural use.*

- *Each household purchase certain amount of land according to equation (3). The land market clears and the population constraint (4) holds.*

- *Households of the same type attain the same utility level regardless of any decision (fertility behavior, community/location choice, etc.) they make.*

- *Each jurisdiction financed its own school through property taxes on residential land. The property tax rate is determined by majority voting. The local government budget balances in all jurisdictions, (5).*

- *School quality depends on both per-student spending and peer effect. The peer effect is a function of the average quality of the children, (6).*

- *All of the adults commute to the CBD for work and earn wage income according to their types. Commuting has both pecuniary and time costs.*

Table 3a Parameter Values

$a = 2.2$	$b = 0.1$	$c = 0.7179$	$w_{BA} = 55$	$w_{HA} = 32$	$w_{NH} = 20$	$\varepsilon = 0.78$
$k_o^{BA} = 0.176$	$k_o^{HA} = 0.166$	$k_o^{NH} = 0.141$	$k_p^{BA} = 0.824$	$k_p^{HA} = 0.834$	$k_p^{NH} = 0.859$	$g = 1$
$\eta = 0.8$	$\alpha_p = 0.04$	$\beta_p = 0.18$	$\gamma = 0.165$	$\alpha_o = 0.2588$	$\beta_o = 0.5761$	$\text{int}\, e = 0.025$
$c_1 = 10$	$c_2 = 1$	$\overline{N_1} = 200000$	$\overline{N_2} = 250000$	$\overline{N_3} = 50000$	$R_a = \$1{,}237$	

Table 3b Statistics and Calibration Results

Target		Real data	Baseline	SFC	PH1	PH2	VC	SFC+PH	SFC+VC
Labor Market-related variables									
Annual Income ($)	NH	51,432	51,233	51,219	46,311	46,837	45,366	48,686	45,234
	HA	87,479	88,288	88,288	87,583	87,522	87,615	87,492	87,607
	BA	155,013	153,394	153,412	152,030	152,075	152,108	152,225	152,232
Time Spent on Working per Day (hour)	NH	7.64	7.02	7.02	6.34	6.42	6.21	6.67	6.20
	HA		7.56	7.56	7.56	7.55	7.56	7.55	7.56
	BA		7.64	7.64	7.63	7.64	7.64	7.64	7.64
Family-related variables									
Fertility Rate	NH	2.521	2.566	2.567	2.604	2.568	2.683	2.464	2.691
	HA	1.918	1.913	1.913	1.915	1.919	1.912	1.921	1.913
	BA	1.652	1.624	1.626	1.604	1.608	1.612	1.625	1.626
Child-care Time Cost per Day (hour)	NH	1.3607 ~ 1.5110	1.8421	1.8427	1.8696	1.8437	1.9261	1.7691	1.9320
	HA		1.3736	1.3736	1.3745	1.3777	1.3728	1.3793	1.3732
	BA		1.1657	1.1670	1.1511	1.1546	1.1573	1.1664	1.1670
Proportion of Expenditure on Children	NH	31% ~ 47%	38.39%		35.44%	35.33%	38.39%	35.29%	38.39%
	HA		43.03%						
	BA		44.77%						

Table 3b (continued)

Target		Real data	Baseline	SFC	PH1	PH2	VC	SFC+PH	SFC+VC
Housing Market-related variables									
Proportion of Total Expenditure on Housing	NH	Around 20%	23.10%		5.82%	5.18%	23.10%	4.93%	23.10%
	HA		23.70%						
	BA		23.92%						
Share of Children's Expenditure on Housing	NH	31%	31%	31%	8.45%	7.55%	31%	7.20%	31%
	HA			31%					
	BA								
Population per Acre		4.63	5.53	5.43	5.82	5.69	5.87	5.24	5.48
Preferred Property Tax Rate	NH	About 1.40%	1.22%						
	HA		1.40%						
	BA		1.47%						

Figure 1 Rent-Distance Curve

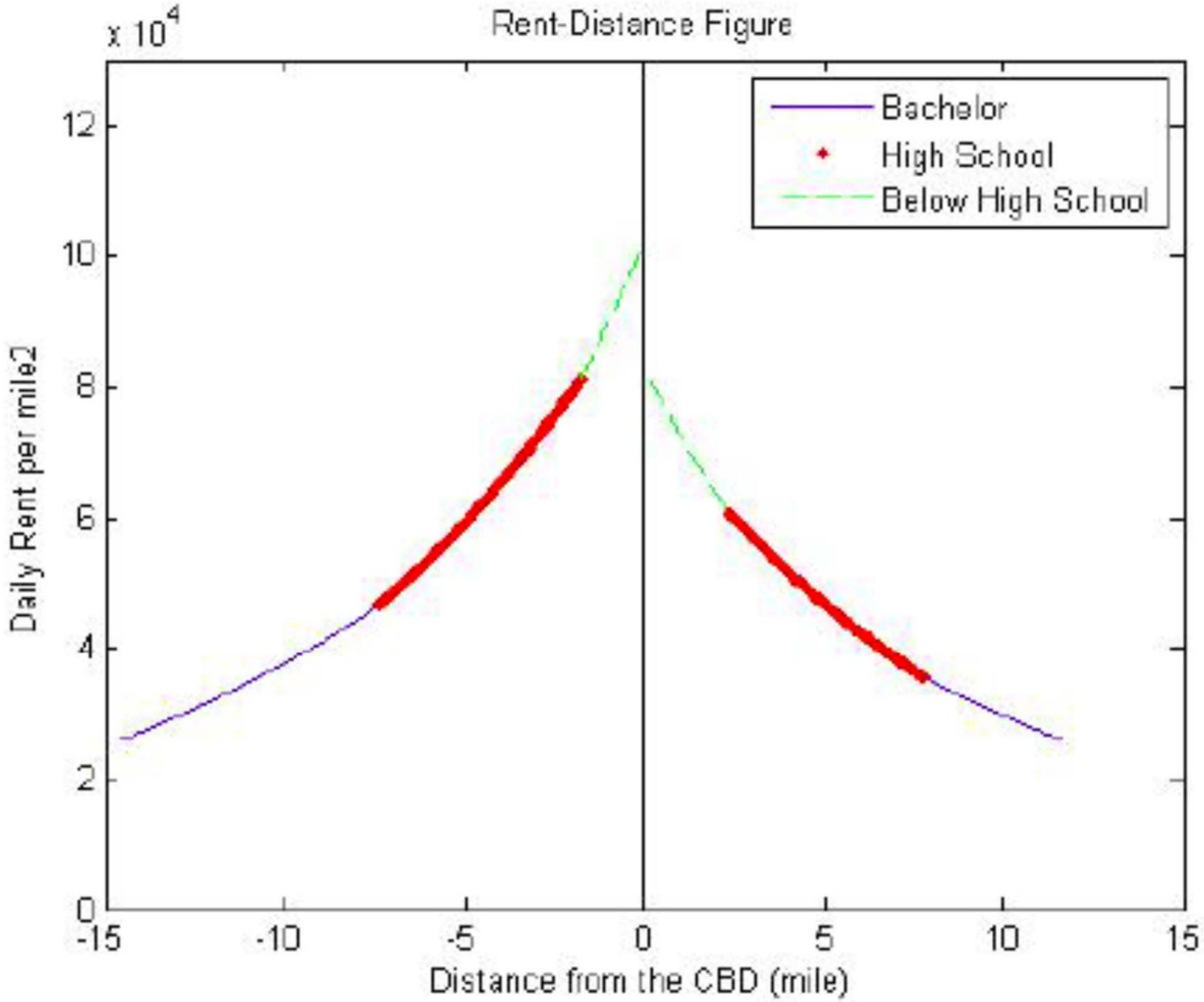


Figure 2 Lot Size-Distance Curve

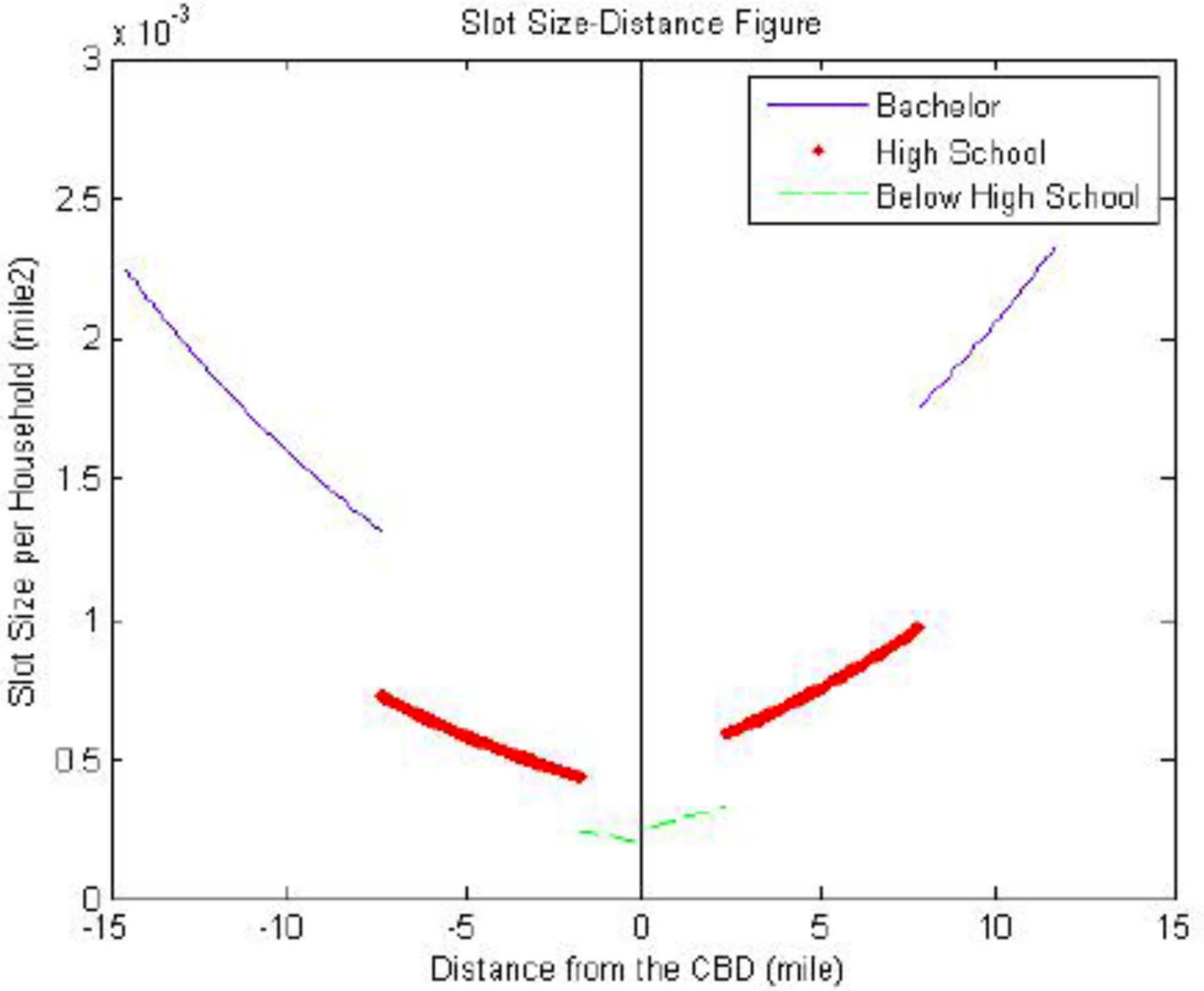


Figure 3 Population Density-Distance Curve

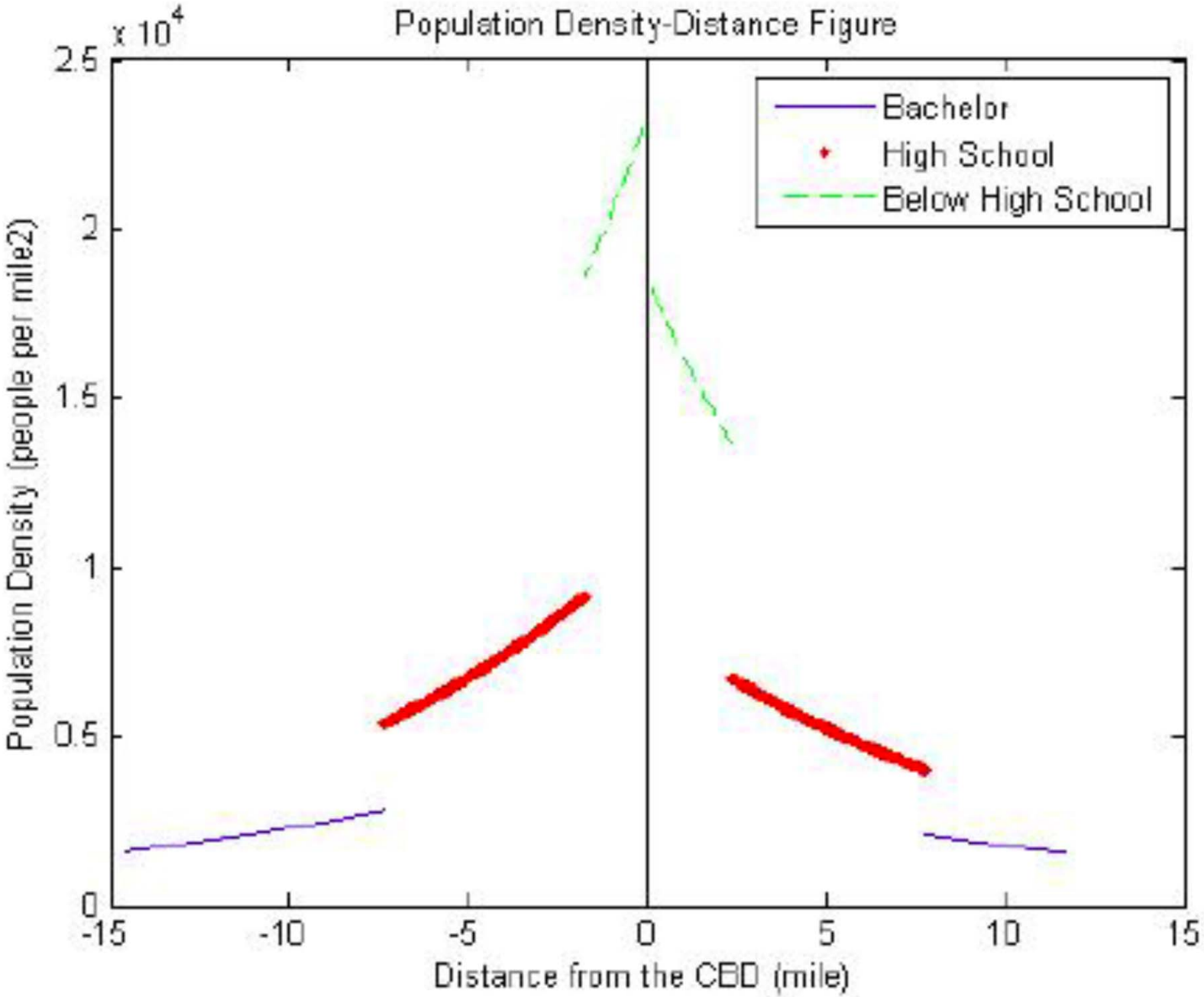


Table 4a Cross-community Welfare Comparison at the Baseline equilibrium

	Total Welfare (Utility level)	Parents' Well-being		Children Education Quality	
		West	East	West	East
NH	10.4342	12.3364	12.4337	0.9857	0.9441
HA	11.4934	13.4727	13.5910	2.3647	2.2709
BA	13.6434	14.9952	15.2109	5.0705	4.6966
Average	12.2474	14.0249		3.0554	

Key 1: NH: Not a high school graduate; HA: High school graduate to Associate degree; BA: Bachelor's degree or above.

Table 4b Equilibrium Outcome Summary

Variables		Baseline	SFC	PH1	PH2	VC	SFC+PH	SFC+VC
Household Distribution								
Number of Household in the West	Group 1	4.26%	5%	0%	0%	2.69%	0%	5%
	Group 2	27.83%	25%	45.35%	39.34%	32.72%	27.66%	25%
	Group 3	28.38%	20%	40%	40%	40%	30.62%	20%
Number of Household in the East	Group 1	5.74%	5%	10%	10%	7.31%	10%	5%
	Group 2	22.17%	25%	4.65%	10.66%	17.28%	22.34%	25%
	Group 3	11.62%	20%	0%	0%	0%	9.38%	20%

Community Comparison							
(W) School Quality/ Property Tax Rate	564/ 1.47%	406/ 1.40%	618/ 1.40%	774/ 1.47%	741/ 1.47%	632/ 1.40%	386/ 1.40%
(E) School Quality/ Property Tax Rate	280/ 1.40%	406/ 1.40%	34/ 1.40%	64/ 1.40%	123/ 1.40%	264/ 1.40%	386/ 1.40%
(W) Average Rent ($)	41,076	39,515	44,709	43,861	43,309	41,212	39,513
(E) Average Rent ($)	37,703	39,515	28,488	29,316	35,172	34,405	39,513
(W) Annual Income ($)	116,192	110,631	117,810	120,090	120,269	121,491	109,219
(E) Annual Income ($)	102,106	110,631	59,255	67,752	75,187	92,726	109,219

Regress model-generated data

- More “test” to check whether the model is doing a good job
- (***idea***) ***Run a regression*** with model-generated data which resembles some existing empirical works with those data. Then ***compare*** the “empirical results” with the literature.
- The negative rent gradient is a natural candidate for such test (Alonso, 1964; Muth, 1969).
- E.g. Eberts and Gronberg (1982) estimates the rent gradients in Chicago around 1970 and finds that rental rate drops by about 9% when the location is 1 mile farther from the CBD.
- Using housing transaction data from 1997 to 2001, Osland, Thorsen, and Gitlesen (2007) confirm the **negative** housing price gradient across specifications.

$$\log R_i = \beta_0 + \beta_D D_i + \beta_w w_i + u_i$$

	Point Estimate (Standard Deviation)	
	West	East
β_0	11.4857 (0.0018)	11.2497 (0.0016)
β_D	-0.0880 (0.0002)	-0.1005 (0.0003)
β_w	-0.0011 (0.0001)	0.0008 (0.0001)
Sample Size	2,800	2,800
R^2	0.9962	0.9951
F-statistics	370,278	286,228

Counter-factual Policy Experiments

- (welfare measure)

We want to find the discount factors/multipliers, χ_t, $t \in \{W, \Omega_o, U\}$, which is needed to be imposed on parents'/children's/both consumption in the new equilibrium so that their well-being/quality/utility equal to that in the baseline equilibrium.

When $\chi_t > 1$, households are worse off in the new equilibrium.

When $\chi_t < 1$ households are better off in the new equilibrium.

Counterfactual Experiments

School Finance Consolidation: Education policy that could affect the Housing market

Equalized per child instructional spending

- Weaken the degree of sorting, in general.
- Positive total welfare effect (measured by utility level)

BAD for the children: Lower property tax rate $\Longrightarrow$ Less educational spending

GOOD for the PARENTS: Weaker sorting $\Longrightarrow$ More effective land use

Table 3b Statistics and Calibration Results

Target		Real data	Baseline	SFC	PH1	PH2	VC	SFC+PH	SFC+VC
Labor Market-related variables									
Annual Income ($)	NH	51,432	51,233	51,219	46,311	46,837	45,366	48,686	45,234
	HA	87,479	88,288	88,288	87,583	87,522	87,615	87,492	87,607
	BA	155,013	153,394	153,412	152,030	152,075	152,108	152,225	152,232
Time Spent on Working per Day (hour)	NH	7.64	7.02	7.02	6.34	6.42	6.21	6.67	6.20
	HA		7.56	7.56	7.56	7.55	7.56	7.55	7.56
	BA		7.64	7.64	7.63	7.64	7.64	7.64	7.64
Family-related variables									
Fertility Rate	NH	2.521	2.566	2.567	2.604	2.568	2.683	2.464	2.691
	HA	1.918	1.913	1.913	1.915	1.919	1.912	1.921	1.913
	BA	1.652	1.624	1.626	1.604	1.608	1.612	1.625	1.626
Child-care Time Cost per Day (hour)	NH	1.3607 ~ 1.5110	1.8421	1.8427	1.8696	1.8437	1.9261	1.7691	1.9320
	HA		1.3736	1.3736	1.3745	1.3777	1.3728	1.3793	1.3732
	BA		1.1657	1.1670	1.1511	1.1546	1.1573	1.1664	1.1670
Proportion of Expenditure on Children	NH	31% ~ 47%	38.39%		35.44%	35.33%	38.39%	35.29%	38.39%
	HA		43.03%						
	BA		44.77%						

Table 3b (continued)

Target		Real data	Baseline	SFC	PH1	PH2	VC	SFC+PH	SFC+VC
Housing Market-related variables									
Proportion of Total Expenditure on Housing	NH	Around 20%	23.10%		5.82%	5.18%	23.10%	4.93%	23.10%
	HA		23.70%						
	BA		23.92%						
Share of Children's Expenditure on Housing	NH	31%	31%	31%	8.45%	7.55%	31%	7.20%	31%
	HA			31%					
	BA								
Population per Acre		4.63	5.53	5.43	5.82	5.69	5.87	5.24	5.48
Preferred Property Tax Rate	NH	About 1.40%	1.22%						
	HA		1.40%						
	BA		1.47%						

Public Housing: Housing market policy that could affect the education

Government take over land at market value and develop housing units for the poor

The program is financed by

1) contribution from program participants

2) income taxes from non-participants

- Enlarge school quality gap between communities
- Benefit the poor at the cost of harming the rich
- Distort the economy $\Longrightarrow$ Less OVERALL welfare

Location of the public housing band matters

All Units in the *East*; Two alternative arrangements

1) Between **4** mile and **6.9** mile away from the CBD

2) Outside the fringe distance

Fringe Distance: The distance beyond which no non-participant would reside

Key Difference: Arrangement **1** reduces amount of accesible land.

- Reducing accesible land leads to

1) Higher market rents; 2) Stronger sorting; 3) More distortion $\Longrightarrow$ Less welfare

Education-Housing market policy package

- Extremely strong sorting hurts the economy.

– Public Housing Policy strengthens the sorting

– School Finance Consolidation mitigates the sorting

What if we combine the two policies?

Compared to public housing policy only

- Milder sorting

- Significant total welfare improvement

Table 6 Equilibrium Welfare Comparison

Variables		Baseline	SFC	PH1	PH2	VC	SFC+PH	SFC + VC
Welfare Comparison								
Total Welfare Change (Consumption-Equivalent Measure %)	Group 1	Benchmark	+0.02	+19.98	+20.22	+18.59	+17.53	+18.93
	Group 2		+0.02	-6.30	-2.69	-2.14	+0.45	-1.62
	Group 3		+0.01	-5.55	-2.26	-2.06	+0.28	-1.62
	Average		+0.02	-3.46	-0.35	-0.19	+1.92	+0.28

Variables		Baseline	SFC	PH1	PH2	VC	SFC+PH	SFC + VC
Change in Parents' Well-being (Consumption-Equivalent Measure %)	Group 1	Benchmark	-0.44	+31.13	+25.81	+25.79	+7.52	+22.89
	Group 2		+0.15	-5.59	-2.08	-1.58	+0.87	-0.91
	Group 3		+1.33	-10.33	-9.02	-7.83	-0.79	+0.36
	Average		+0.61	-3.45	-1.98	-1.27	+0.78	+2.05
Change in Children' Quality (Consumption-Equivalent Measure %)	Group 1	Benchmark	+0.75	-10.54	+8.12	-8.13	+39.92	-0.33
	Group 2		-0.24	-6.96	-3.63	-2.66	-1.02	-2.74
	Group 3		-2.28	+3.45	+8.58	+7.14	+1.74	-4.93
	Average		-1.30	-1.78	+3.62	+1.85	+3.58	-4.63

Short-run inflexibility…

Table 7 Flexibility of Various Choices

Type of Goods	Short-run	Long-run
Fertility Rate	Inflexible	Flexible
Lot Size	Inflexible	Flexible
Rental Rate	Inflexible	Flexible
Residential Location	Inflexible	Flexible
Non-durable Good	Flexible	Flexible
Leisure	Flexible	Flexible
Property Tax Rate	Flexible	Flexible
School Quality	Flexible	Flexible

Table 8a Short-run VS Long-run (Statistics)

Statistics		Baseline	SFC		VC		SFC + VC	
			SR	LR	SR	LR	SR	LR
Annual Income ($)	Group 1	51,233	51,170	51,219	44,990	45,366	44,927	45,234
	Group 2	88,288	88,149	88,288	88,428	87,615	88,289	87,607
	Group 3	153,394	153,090	153,412	153,645	152,108	153,339	152,232
Annual Consumption ($)	Group 1	38,554	38,576	38,567	40,752	40,311	40,773	40,434
	Group 2	64,227	64,279	64,224	63,660	63,678	63,712	63,696
	Group 3	110,175	110,293	110,299	109,197	108,505	109,315	109,415
Hours Worked per Day	Group 1	7.02	7.01	7.02	6.16	6.21	6.15	6.20
	Group 2	7.56	7.55	7.56	7.57	7.56	7.56	7.56
	Group 3	7.64	7.62	7.64	7.65	7.64	7.64	7.64

Table 8a Short-run VS Long-run (Statistics)

Statistics		Baseline	SFC		VC		SFC + VC	
			SR	LR	SR	LR	SR	LR
Property Tax Rate	West	1.47%	1.40%	1.40%	1.47%	1.47%	1.40%	1.40%
	East	1.40%	1.40%	1.40%	1.40%	1.40%	1.40%	1.40%
Peer Quality	West	38.67	30.18	30.75	38.02	48.08	29.87	29.62
	East	23.73	30.18	30.75	23.61	15.11	29.87	29.62
School Quality	West	564	394	406	554	741	390	386
	East	280	394	406	279	123	390	386

Table 8b Short-run VS Long-run (Welfare)

Variables			Baseline	SFC		VC		SFC + VC	
				SR	LR	SR	LR	SR	LR
Welfare Comparison									
Total Welfare Change (Consumption-Equivalent Measure %)	Group 1	W	Benchmark	-3.07	+0.02	+19.01	+18.59	+16.55	+18.93
		E		+3.30	+0.02	+19.16	+18.59	+21.79	+18.93
	Group 2	W		-3.53	+0.02	-1.30	-2.14	-4.80	-1.62
		E		+3.72	+0.02	-1.17	-2.14	+2.54	-1.62
	Group 3	W		-3.70	+0.01	-1.33	-2.06	-5.00	-1.62
		E		+3.88	+0.01	-1.18	N.A.	+2.69	-1.62
	Average			-0.70	+0.02	+0.62	-0.19	-0.04	+0.28

Key 1: Group 1: Not a high school graduate; Group 2: High school graduate to Associate degree; Group 3: Bachelor's degree or above.

Table 8b Short-run VS Long-run (Welfare)

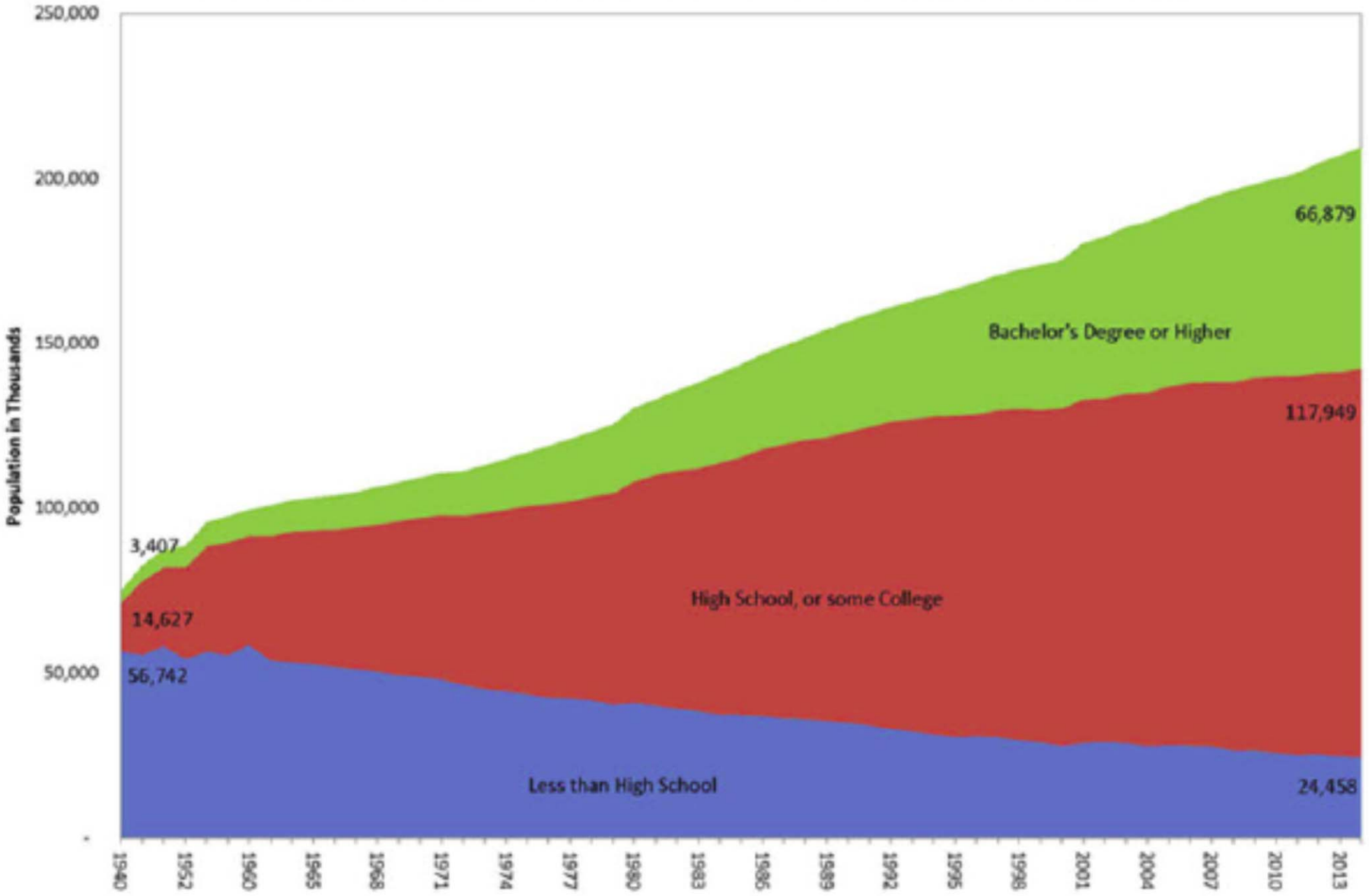
Variables			Baseline	SFC		VC		SFC + VC	
				SR	LR	SR	LR	SR	LR
Change in Parents' Well-being (Consumption-Equivalent Measure %)	Group 1	W	Benchmark	+0.71	+2.05	+25.55	+21.61	+26.06	+24.80
		E		0	-2.32	+25.63	+26.58	+25.63	+21.45
	Group 2	W		+0.78	+2.28	-1.25	-3.76	-0.26	+1.25
		E		0	-2.58	-1.26	+3.68	-1.26	-3.66
	Group 3	W		+0.80	+3.59	-1.29	-5.26	-0.27	+2.64
		E		0	-4.38	-1.27	N.A.	-1.27	-5.40
	Average			+0.48	+0.61	+1.52	-1.27	+2.00	+2.05
Change in Children' Quality (Consumption-Equivalent Measure %)	Group 1	W	Benchmark	-10.69	-3.56	+4.92	+1.08	-5.04	-4.68
		E		+9.28	+3.91	+5.26	-10.23	+13.93	+2.87
	Group 2	W		-10.68	-3.37	-1.38	+0.16	-11.99	-5.95
		E		+9.28	+3.64	-1.04	-11.02	+8.20	+1.24
	Group 3	W		-10.67	-6.22	-1.38	+3.56	-11.99	-8.97
		E		+9.28	+7.00	-1.04	N.A.	+8.20	+4.60
	Average			-2.96	-1.30	-0.97	+1.85	-3.88	-4.63

Concluding Remarks

- This paper: **combines** Becker (***endogenous fertility***) with Hanushek-Yilmaz (which Alonso-Muth and Tiebout)
- ***Reasonable match with data***
- Policy experiment: combining **housing policy** (e.g. public housing) with **education policy** (school finance consolidation) will generate better outcomes
- (*Directions for future research*)

- *THANK YOU* VERY MUCH FOR YOUR ATTENTION and COMMENTS

Figure 1: Population Age 25 and over by Educational Attainment: 1940-2014



Sources: U.S. Census Bureau. 1947, 1952-2002 March Current Population Survey, 2003-2014 Annual Social and Economic Supplement to the Current Population Survey; 1940-1960 Census of Population.

United States Census Bureau

Table A Variables and Parameters

Symbol	Interpretation	Symbol	Interpretation
S_p	lot size for parents	α_p	weight of S_p in the parents' well-being
Z_p	consumption goods for parents	β_p	weight of Z_p in the parents' well-being
l	leisure time	η	weight of l in the parents' well-being
q	educational quality	γ	weight of q in the offspring's quality
S_o	lot size for offspring	α_o	weight of S_o in the offspring's quality
Z_o	consumption goods for offspring	β_o	weight of Z_o in the offspring's quality
n_o	number of offspring	k_p	weight of parents' well-being in the utility function
$g(n_o) = gn_o^{-\varepsilon}$	degree of altruism toward each child	k_o	weight of offspring's quality in the utility function
$C(n_o) = cn_o$	time cost of bearing n_o offspring	a	per mile pecuniary cost
w	hourly wage	b	per mile commuting time cost
r	distance from the CBD		