Fertility, Housing, and Location Decisions

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Housing and Fertility

Newsweek

Nation World Lifestyle Opinion Rankings

News Birth Rate Population Demographics Population Growth Housing Housing Ma

News Article

US Birth Rate Warning Issued Over House Prices

Housing Market | Real Estate 4 minute read

US birth rate hits record low, housing costs weigh on family planning

The 2008 financial crisis pushed both housing and fertility

POLICY

Will cheap housing lead to more babies?

The connection between housing and fertility rates has a missing piece.

Renting a home 'leads to lower birth rates'

Housing, fertility, and tenure choice

Housing matters for fertility

- A key margin is tenure choice (owning vs. renting). At MSA level:
  - Dettling and Kearney (2014): \$10k ↑ house-price
    ⇒ owners +5% births, non-owners -2.4 %;
  - Lovenheim and Mumford (2013) \$100k ↑ housing wealth
    ⇒ $P(child)$ ↑ 16–18%; no effect for renters
- Tenure, location, and physical space are linked
  - van Doornik et al. (2024) (Brazil): winning access to housing
    ⇒ +3.8% probability of having a child (+32% ages 20–25);
    Increase is stronger in areas with lower quality housing, greater rent/income
- Empirical evidence cumulates, but lack of structural analysis
  - How do housing and fertility interact? How much does own vs rent impact?
    Housing affordability heterogeneous in space: effects on fertility and moving?
  - What are good policies to help fertility? Could they have unintended effects?

Today

Empirics: document facts about fertility, housing, and moving

- From Cross-sectional data (ACS):
  - Fewer births in metro areas, more moves out of them after having kids
  - Parents move to comparatively cheaper places with lower wages
- From Longitudinal data (PSID):
  - New parents transition to owning, but less were housing is more expensive
  - Size of the house very important for moves after childbirth
    - More moves "for size" take place
    - New parents move to bigger houses

Model: develop a model of location and tenure choice with fertility

- Childbirth increases housing demand
- Realistic housing markets with mortgages, tenure choice and transaction costs
- Moving patterns and agglomeration affected by fertility events

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Data

- **American Community Survey (ACS) 1-year estimates:**
  - Annual survey data collected by the U.S. Census Bureau since 2005.
  - Geographic detail up to PUMA level
  - Demographic characteristics, socioeconomic indicators, and housing information.
- **Panel Study of Income Dynamics (PSID):**
  - Longitudinal household survey initiated in 1968 (24000 households in 2021)
  - Follows original sample families and their descendants across generations
  - Rich demographics, income and wealth information
  - Applied to get specific geography

From the ACS: Living in Principal City of a Metro Area

5 year horizon

$$\text{MetroPrincipalStatus}_{it} = \beta_0 + \beta \cdot \underbrace{\text{New Parent}_{it}}_{\text{Eldest Child} \leq 3} + \tau_t + \gamma \cdot \text{age}_{it} + \delta X_{it} + \varepsilon_{it}$$

	(1)	(2)	(3)
	Lives in	Moved to	Left from
New Parent	-0.0598***	-0.0154***	0.0384***
	(0.001)	(0.001)	(0.003)
Constant	0.177***	0.0434***	0.230***
	(0.003)	(0.007)	(0.013)
Controls	Yes	Yes	Yes

Standard errors in parentheses

Only non-parents and new parents

Controls; income, education, employment, status and sex.

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

New parents:

- Less likely to live in Metro Area
- Less likely to move to it
- More likely to move out of it
- Drop in probability 4 pts

From the ACS: Living in Principal City of a Metro Area

5 year horizon

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New parents:

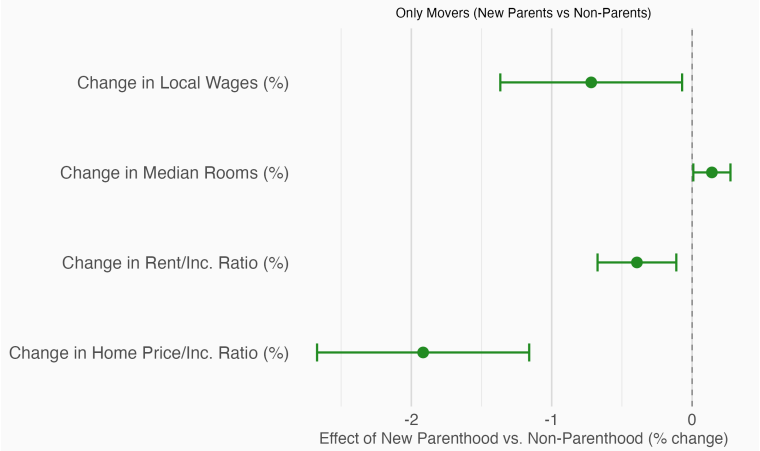
- Less likely to live in Metro Area
- Less likely to move to it
- More likely to move out of it
- Details and Robustness Means

Parenthood and moving

Baseline | Older Parents

For MSA characteristic Y, for a person i moving from origin o to destination d, with controls X, run

$$\Delta Y_{it}^{d(i),o(i)}\% = \beta_0 + \beta \text{NewParent}_{it} + \tau_t + \gamma \cdot \text{age}_{it} + \delta X_{it} + \varepsilon_{it}$$



Congestion and Homeownership

Means

$$\text{Owner}_{it} = \beta_0 + \beta \cdot \text{New Parent}_{it} + \text{New Parent}_{it} \cdot \text{MSA congestion}_{it} + \tau_t + \gamma \cdot \text{age}_{it} + \delta X_{it} + \varepsilon_{it}$$

	(1)	(2)
	Homeowner	Homeowner
New Parent	0.069***	0.072***
	(0.005)	(0.005)
New Parent×Inverse H^s *elasticity*	-0.020***	
	(0.004)	
New Parent×Density		-0.009**
		(0.003)
R^2	0.124	0.124

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Controls: Income, education, employment status and sex

Using the PSID: event study regressions

- Objective: estimate the effect of childbirth on housing-related outcomes
- Strategy: event study regressions
- For individual i, define E_i the year in which they have a child.
  We can then estimate for any outcome Y the event study regression

$$Y_{it} = \sum_{j=-5, j\neq -2}^{10} \alpha_j \cdot \mathbf{1}[t - E_i = j] + \zeta_i + \delta X_{it} + \tau_t + \gamma_{h(i)} + \varepsilon_{it}$$

  where ζ_i, τ_t, and $h(i)$ are individual, time and age fixed effects, and X_{it} are controls.
- α_j: effect on Y of being j years away from birth compared to being -2 years away

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- α_j: effect on Y of being j years away from birth compared to being -2 years away

PSID: Homeownership Around First Birth

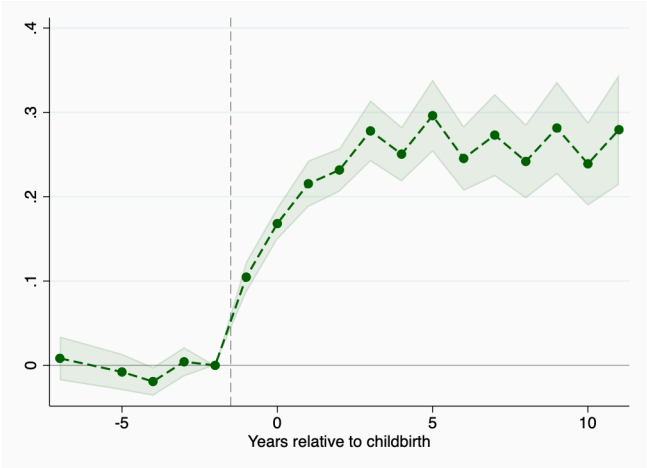


Figure: Homeownership on First Childbirth

Childbirth and reasons to move

Details | No IDFE

Movers are asked: "What is the main reason you moved?".

y axis: α_j (effect of being j years away from birth, compared to -2)

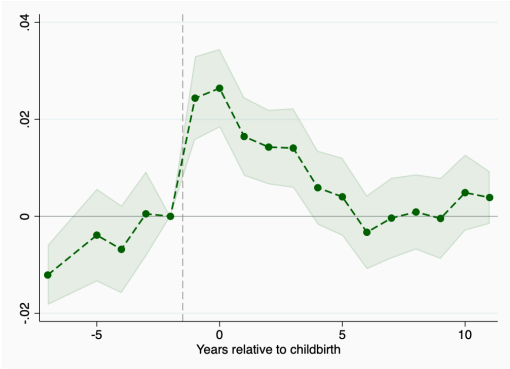


Figure: "Main reason is expansion of housing" on First Childbirth

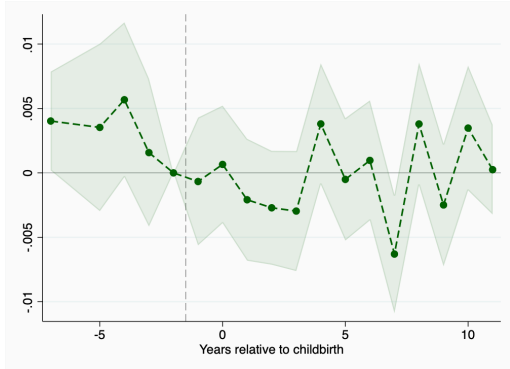


Figure: "Main reason is quality of neighborhood" on First Childbirth

Childbirth and number of rooms

No IDFE

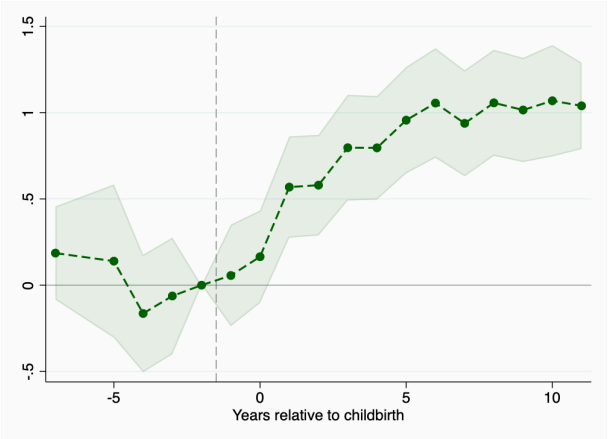


Figure: Number of rooms on First Childbirth

Taking stock

- Literature gives evidence that housing matters for fertility
- Tenure margin is important
- From ACS: new parents move out of city centers, to cheaper places, lower wages
- From PSID: new parents transition to owning, and move to bigger houses
- Many forces at play. A model:
  - Can help discipline, quantify, and disentagle them
  - Can be used to think about policy

A model of housing, fertility, and location

- Introduce realistic housing and tenure choice into models of fertility and space
- Build a lifecycle model with tenure choice, fertility, and location
- Build on recent models (Greaney et al., 2025):
  - Discrete-continuous time method
  - Time is continuous, but some decisions only happen at specific ages
- Today, just build and dicuss the model
- Next steps: characterize and think about policy

Locations, Ages, and Shock Ages

- Finite set of locations $\mathcal{I} = \{1, \ldots, I\}$ with
  - productivity $A_i > 0$
  - amenities $E_i > 0$ and moving costs $\mu_{ii'}$
  - housing supply elasticity $\varepsilon_i > 0$
- Continuous age $a \in [0, A]$; calendar time t.
- **Shock ages** $\mathcal{A}^s = \{0, 1, \ldots, A-1\}$: adjust fertility, location, and owner size
- Work for $a \in [0, A_R]$, retire thereafter; fertile for $a \in [0, A_f]$.
- Child age $a_n \in [0, A_m]$ (maturity at A_m); Can only have kids once;

Preferences and Housing Services

Housing services: $\mathbf{h} = \chi h + h^R$, $\chi > 0$. Flow utility:

$$u(c, \mathbf{h}; n) = \frac{c^{1-\sigma}}{1-\sigma} + \kappa_h(n)\frac{\mathbf{h}^{1-\sigma}}{1-\sigma}, \quad \kappa_h'(n) \geq 0.$$

- Constraints: $c \geq 0$, $h^R \geq 0$; if $h > 0$ then $h^R = 0$ (you either own or rent).
- Housing depreciates at rate δ; transaction cost ψ on trades.

Earnings and production

- Earnings by city i and age a:

$$y_t(i,a) = \mathbf{1}\{a < A_R\}\,(1-\tau_{\text{pay}})\,w_{it} \;+\; \mathbf{1}\{a \geq A_R\}\,\bar{b}_i.$$

- Production with agglomeration:

$$Y_{it} = A_i\,Z_i(L_{it})\,L_{it}, \qquad Z_i(L) = L^{\alpha_i} \;\Rightarrow\; w_{it} = A_i\,Z_i(L_{it}) = A_i\,L_{it}^{\alpha_i}.$$

- Pay-as-you-go budget (financing pensions):

$$\sum_i \tau_{\text{pay}}\,w_{it}\,L_{it} \;=\; \sum_i \bar{b}_i\,R_{it},$$

where L_{it} is the mass of workers and R_{it} the mass of retirees.

Portfolio and Savings

- Households can purchase a bond or shares in a real estate trust
- All assets have ex ante return q so households are indifferent, invest f, $1 - f$
- Exogeneous interest rate equal to q
- Collateral (LTV) on ownership: $b \geq -\phi\, p_{it} h$;

Bequests and entrants income

- At death, agents get a warm-glow utility

$$v_T(b) = \frac{\kappa_T \left(b + (1-\psi)ph\right)^{1-\sigma}}{1-\sigma}$$

- Aggregate local estates and recycling to entrants:

$$B_i = \int \left(b + (1-\psi)\, p_i h\right) d\mathcal{D}_i(b,h), \qquad T_i = \frac{B_i}{N_I^0}$$

  where N_i^0 is the flow of newborn entrants in i.

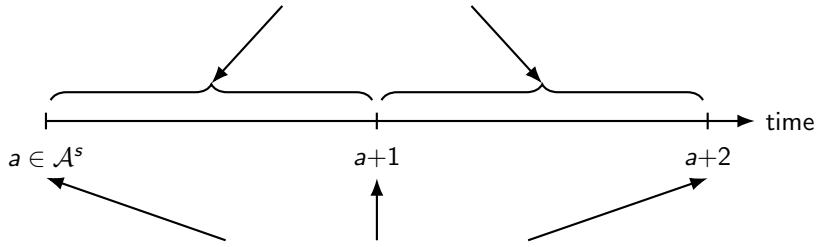
- Entrants all start as renters with $h_0 = 0$):

$$b_0(i) = T_i, \qquad h_0 = 0.$$

Timing of Decisions

Between shock ages:

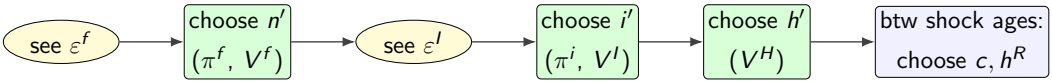
1. Choose consumption c and rental housing h^R
2. Choose savings in liquid asset b



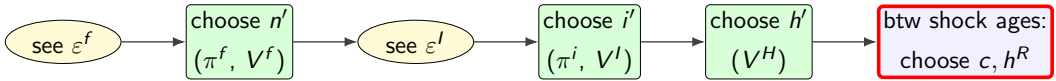
At shock ages:

1. Receive shocks $\{\varepsilon^f, \varepsilon^l\}$
2. Choose fertility, location and owner-occupied housing h

The household's problem



The household's problem between shock ages



The household's state is $\Omega = (b, h, i, a, n, a_n)$. Between shock ages, the HJB satisfies

$$\rho V_t(\Omega) = \max_{c,\, h^R} \Big\{ \; u\big(c, \chi h + h^R\big) + \frac{\partial V_t(\Omega)}{\partial b}\, \dot{b} + \frac{\partial V_t(\Omega)}{\partial a} + \frac{\partial V_t(\Omega)}{\partial a_n} + \frac{\partial V_t(\Omega)}{\partial t} \; \Big\}$$

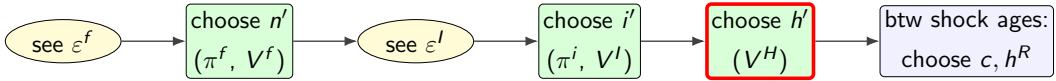
$$\text{s.t. } \dot{b} = y_t(i, a) + q\, b - c - r_{it}\, h^R - (\delta + \tau_H)\, p_{it} h,$$

$$\dot{b} > 0 \quad \text{if} \quad b \leq -\phi p_{it} h, \quad \text{and} \quad h^R = 0 \quad \text{if} \quad h > 0.$$

Between shock ages, the density $g_t(\Omega)$ satisfies the KFE:

$$\frac{\partial}{\partial t}\, g_t(\Omega) = -\frac{\partial}{\partial b}\Big(g_t(\Omega)\, \dot{b}(\Omega)\Big) \; - \; \frac{\partial}{\partial a}\, g_t(\Omega) \; - \; \frac{\partial}{\partial a_n}\, g_t(\Omega),$$

The household's problem at shock ages: Owner-size



At shock ages, the last choice is to pick

$$\tilde{h}_t(\Omega) = \arg \max_{h' \in \mathcal{H}_t(b,h,i)} V_t\big(\tilde{b}_t^H(b,h,h',i), h', i, a, n, a_n\big)$$

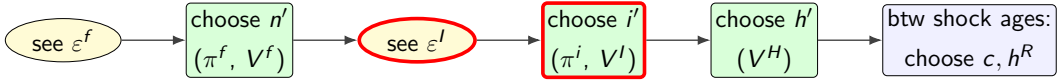
Where $\tilde{b}_t^H$ is the liquid wealth immediately after the adjustement,

$$\tilde{b}_t^H(b,h,h',i) = b + \mathbb{I}\{h' \neq h\}[(1-\psi)p_{it}h - p_{it}h']$$

So the density of state variables after this stage is

$$g_t^H(\Omega) = \iint \mathbf{1}\big\{b' = \tilde{b}^H(b',h',h,.),\ \ h' = h\big\}\, g_t^I(b',h',.)\, db'\, dh'.$$

The household's problem at shock ages: Location



Households draw idiosyncratic location taste shocks $\{\varepsilon_i^l\} \sim$ Frechét(ν^l).

Expected value of the optimal residential location is Details

$$V_t^l(\Omega) = \Gamma\Big(1-\tfrac{1}{\nu^R}\Big)\Bigg(\sum_{i'\in\mathcal{L}} \big[V_t^H(\Omega(i'))E_{i'}\,\mu_{ii'}\big]^{\nu^l}\Bigg)^{1/\nu^l}.$$

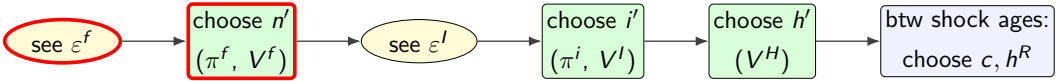
Shares are

$$\pi^l(i' \mid \Omega) = \frac{V^H(\Omega(i'))^{\nu^l}}{\sum_{k\in\mathcal{I}} V^H(\Omega(i'))^{\nu^l}},$$

So the density of state variables after this stage is

$$g_t^l(\Omega) = \sum_{i'} \iint \mathbf{1}\big\{b' = \tilde{b}(\Omega(i')),\ h' = \tilde{h}(\Omega(i'))\big\}\,\pi^l(i' \mid \Omega)\,g_t^f(b', h', i', \cdot)\,db'\,dh'.$$

The household's problem at shock ages: Fertility



The first decision is fertility. Idiosyncratic fertility shocks $\varepsilon^f \sim$ Frechét(ν^f).

$$V^f(b,h,i,a,n,a_n) = \Gamma\Big(1-\tfrac{1}{\nu^f}\Big)\left(\sum_{n'\in\mathcal{N}}\left[V^I(b,h,i,a,n',a_n)\right]^{\nu^f}\right)^{1/\nu^f}.$$

$$\pi^f(n' \mid \Omega) = \frac{\left[V^I(b,h,i,a,n',a_n)\right]^{\nu^f}}{\sum_{k\in\mathcal{N}}\left[V^I(b,h,i,a,k,a_n)\right]^{\nu^f}}$$

$$g^f_t(\cdot,n') = \left[\lim_{\iota\downarrow 0} g_{t-\iota}(\cdot,\ a-\iota,\ 0,\ a_n)\right]\pi^f(n' \mid \Omega).$$

Construction and floorspace market clearing

Housing is produced according to

$$\Upsilon_{it} = Z_{it}^{h}\, C_{it}, \qquad \Upsilon_{it} \geq 0, \qquad \text{unit cost} = \frac{1}{Z_{it}^{h}}.$$

$$\dot{H}_{it} \;=\; \Upsilon_{it} - \delta\, H_{it}.$$

Floorspace demand (after owner-size update)

$$H_{it}^{d} = \iiint \left(h^{R}(\cdot) + h\right)\, g_{t}^{H}(b, h, i, a, n, a_n)\, db\, dh\, da.$$

Clearing

$$\Upsilon_{it} = \frac{\partial}{\partial t} H_{it} + \delta H_{it}, \qquad \begin{cases} p_{it} = \frac{1}{Z_{it}^{h}} \text{ and } \Upsilon_{it} > 0, \\ \text{or } \; p_{it} < \frac{1}{Z_{it}^{h}} \text{ and } \Upsilon_{it} = 0. \end{cases}$$

REITs and user cost

REITs:

- Own the structure and rent it competitively
- Borrow on an external credit market at rate q and set rents to satisfy the user-cost condition:

$$r_{it} \;=\; (q + \delta + \tau_H)\, p_{it} \;-\; \frac{\partial}{\partial t} p_{it}.$$

Equilibrium (levels)

An equilibrium is a collection of values $V_t(\Omega)$, policies $(c, h^R), (\pi^f, \pi_l)$, distributions $g_t(\Omega)$, prices $\{p_{it}, r_{it}, w_{it}\}_i$,
such that:

- Households and firms optimize
- The density of state variables is consistent with optimization
- Markets clear

Balanced Growth Path

Let $\gamma > 0$ and define hats by $\hat{z} \equiv e^{-\gamma t} z$. A BGP is a number γ and functions $\left(v,\ \hat{c},\ \hat{h}^R,\ s^f,\ s_I,\ \phi,\ \{\hat{p}_i, \hat{r}_i, \hat{w}_i\}_{i \in \mathcal{L}}\right)$ such that, for all t and $\hat{\Omega} = (i, a, n, a_n)$,

$$
\begin{aligned}
V_t(\Omega) &= e^{\gamma t}\, v(\hat{b}, \hat{h}, \hat{\Omega}), \\
c_t(\Omega) &= e^{\gamma t}\, \hat{c}(\hat{b}, \hat{h}, \hat{\Omega}), \\
h^R_t(\Omega) &= e^{\gamma t}\, \hat{h}^R(\hat{b}, \hat{h}, \hat{\Omega}), \\
\pi^f_t(\Omega) &= s^f(\hat{b}, \hat{h}, \hat{\Omega}), \\
\pi_{I,t}(\Omega) &= s_I(\hat{b}, \hat{h}, \hat{\Omega}), \\
g_t(\Omega) &= e^{-2\gamma t}\, \phi(\hat{b}, \hat{h}, \hat{\Omega}), \\
p_{it} = e^{\gamma t}\, \hat{p}_i, &\qquad r_{it} = e^{\gamma t}\, \hat{r}_i, \qquad w_{it} = e^{\gamma t}\, \hat{w}_i.
\end{aligned}
$$

These objects satisfy the stationary HJB/KFE and market-clearing conditions written in hats.

Details

Next steps

- Characterize the model: what does γ depend on? What can we say about the distribution of wealth, housing, and fertility?

- Solve the model numerically (in process) and quantify
- Use the model to think about policy experiments. Examples:
  - How do housing subsidies affect fertility and location choices?
  - How do family policies (e.g. child benefits) affect housing and location choices?
  - What are potential macro effects? Could there be consequences on growth?

Conclusion

- Empirical evidence that childbirth affects housing and location choices
- Model of housing, fertility, and location choice with owning/renting
- Next steps: characterize the model, think about policy experiments

Potential reasons to move in PSID questionnaire

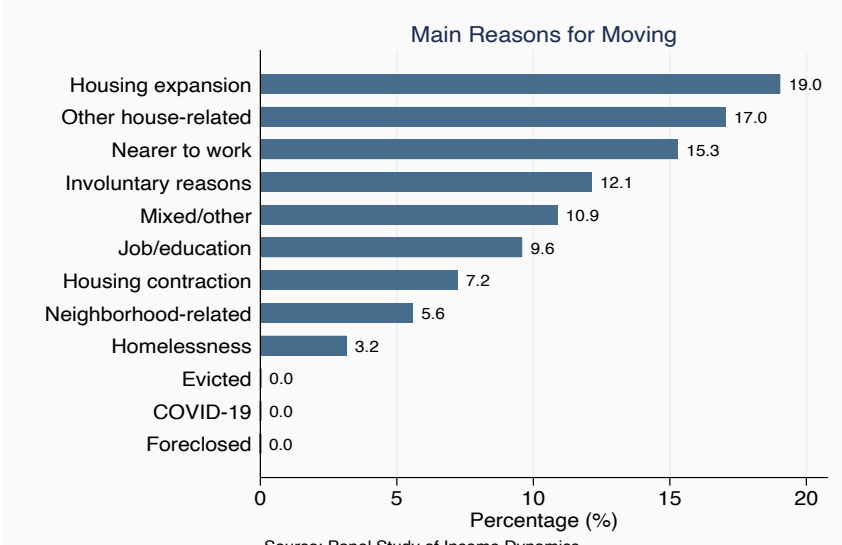
Back

- Purposive productive reasons: to take another job; transfer; stopped going to school
- To get nearer to work
- Purposive consumptive reasons–expansion of housing: more space; more rent; better place
- Purposive consumptive reasons–contraction of housing: less space; less rent
- Purposive consumptive–other house-related: get own home/place; got married; physical conditions of the previous housing unit
- Purposive consumptive–neighborhood-related: better neighborhood; go to school; to be closer to friends and/or relatives
- Response to outside events (involuntary reasons): HU coming down; armed services, etc.; health reasons; divorce; retiring because of health
- Ambiguous, mixed, or other reasons, including reasons such as to save money, all my old neighbors moved away, retiring
- Became homeless or no longer homeless
- COVID-19 or coronavirus

Potential reasons to move in PSID questionnaire(Ctd.)

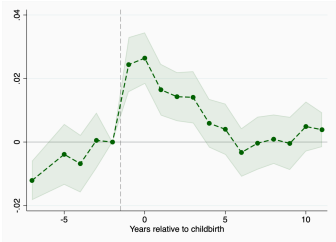
Back

This tabulates the values only for non-parents (both 'never' and 'not yet')

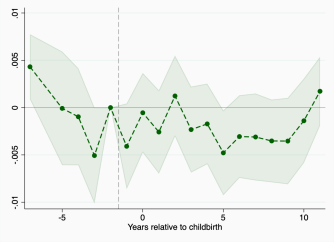


Source: Panel Study of Income Dynamics

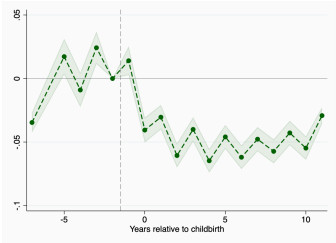
Event Studies: Housing and Location Reasons



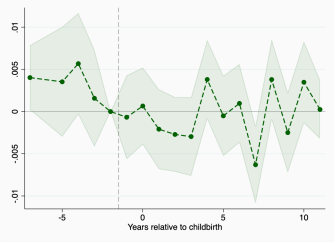
Expansion of housing



Contraction of housing

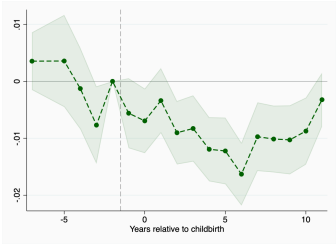


Other house-related

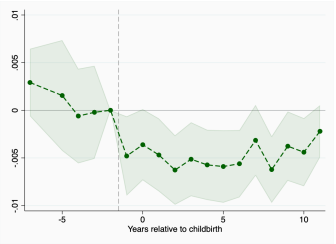


Neighborhood

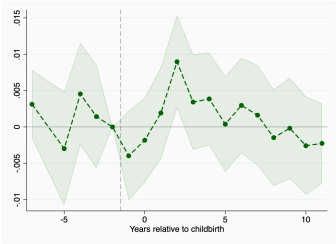
Event Studies: Work and Involuntary Reasons



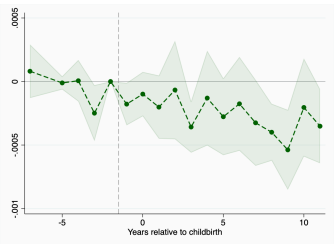
Productive reasons



To get nearer to work

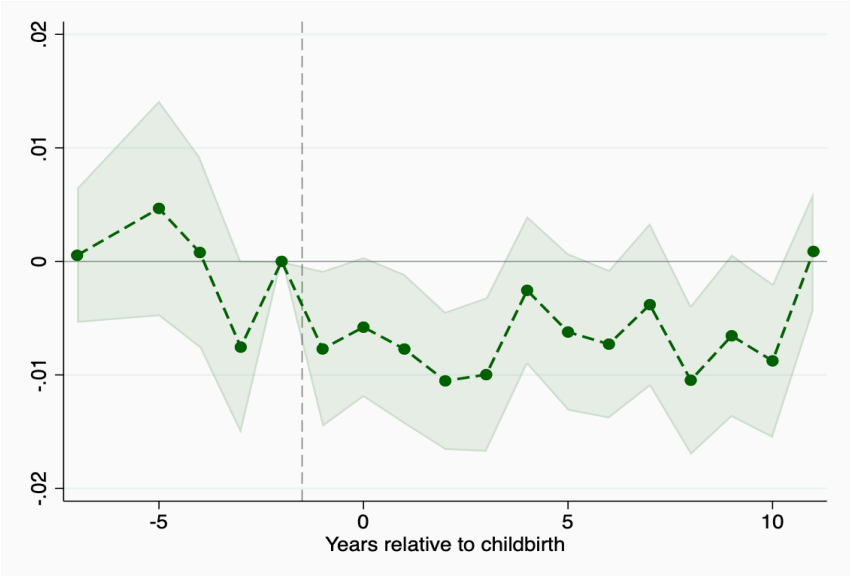


Involuntary reasons



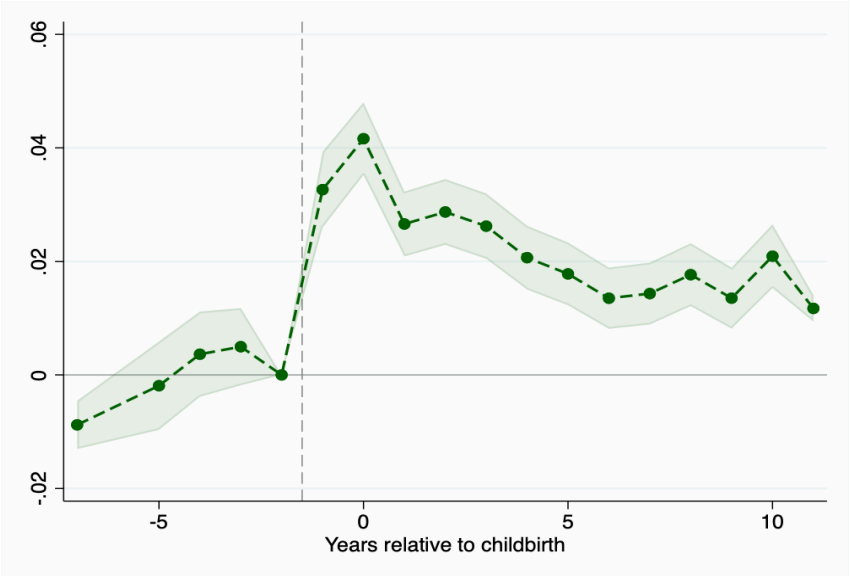
Was evicted

Event Studies: Other Reasons



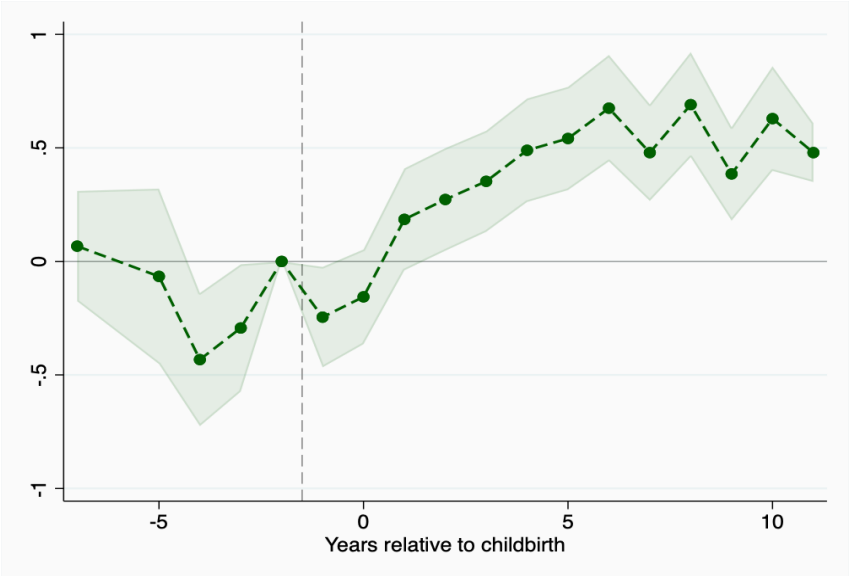
Reasons to move and first childbirth with no individual FE

Back



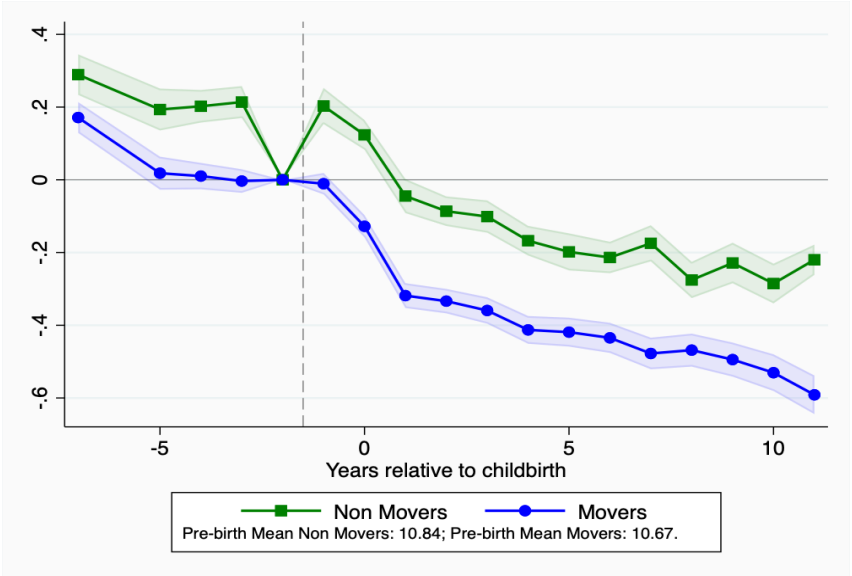
Number of rooms and first childbirth with no individual FE

Back



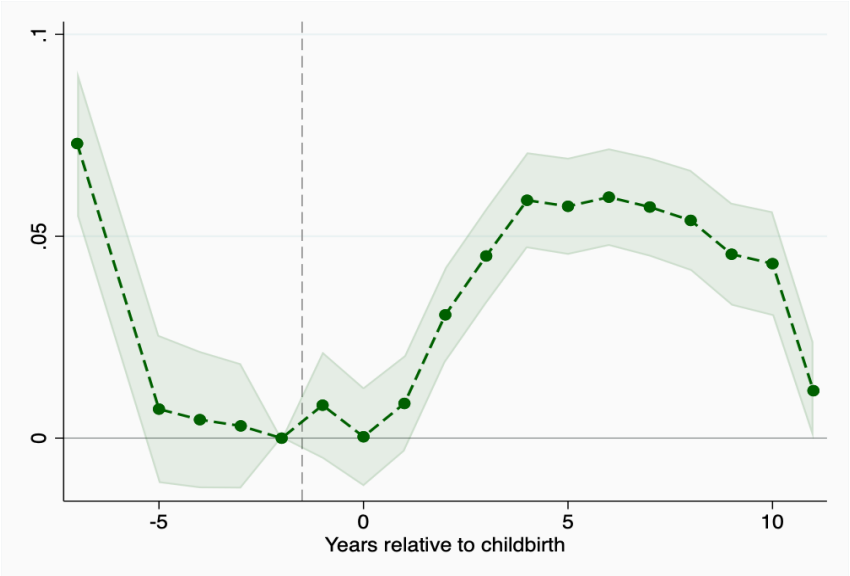
Income and first childbirth with no individual FE

Back



Ownership and first childbirth with no individual FE

Back



Robustness: children and moving

Back

	(1) Number of rooms	(2) Number of rooms	(3) Number of rooms	(4) Number of rooms
Had First Child=1	-0.114***	-0.296***		
	(0.010)	(0.012)		
Moved in last 5 years=1	-1.729***	-0.986***	-1.790***	-1.024***
	(0.006)	(0.009)	(0.007)	(0.009)
Had First Child=1 × Moved in last 5 years=1	0.0795***	0.0777***		
	(0.017)	(0.019)		
Child less than 5=1			0.0995***	-0.0520***
			(0.004)	(0.005)
Child less than 5=1 × Moved in last 5 years=1			0.287***	0.250***
			(0.007)	(0.008)
Constant	6.763***	6.444***	6.763***	6.444***
	(0.009)	(0.014)	(0.009)	(0.014)
Observations	9158333	7557197	9158333	7557197

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Urban status using little kid as regressor

back

	(1)	(2)	(3)
	Lives in	Moved to	Left
littlechild_var	-0.0633***	-0.0152***	0.0379***
	(0.001)	(0.001)	(0.003)
Constant	0.175***	0.0440***	0.228***
	(0.003)	(0.006)	(0.012)
Controls	Yes	Yes	Yes

Standard errors in parentheses

Only non-parents and new parents

Controls include income, education, employment status, sex, and county.

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Details on Metro Status

Back

Variable *metro* in the ACS has four possible categories:

1. In Metropolitan Area, Principal City
2. In Metropolitan Area, Not Principal City
3. In Metropolitan Area, Principal City status not determinable
4. Not In metropolitan area

I define $MetroPrincipalStatus = 1$ for cases 1 and 3.

Alternative: set to 1 only for case 1 (drop 3):

	(1) Lives in	(2) Moved to	(3) Left
New Parent	-0.0598***	-0.00203***	0.00281
	(0.001)	(0.000)	(0.002)
Constant	0.177***	-0.000664*	0.0235**
	(0.003)	(0.000)	(0.008)
Controls	Yes	Yes	Yes

Parenthood and moving: destination characteristics

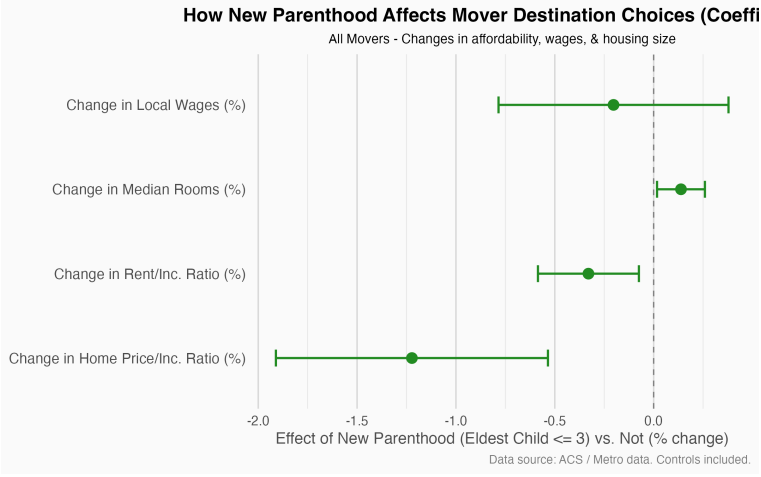
Back

Table:
ab:tab:appendix$_s ummary_s tats_N PvN_a ge3 WeightedAverageOriginLevelsandPercentageChangesforMovers$
$NewParents(EldestChild_i{=}3) vs. Non - Parents(Unadjusted)$

Variable	Non Parents		New Parents	
	Origin	Change (%)	Origin	Change (%)
Local Wages / Income	63745.77	5.08	63276.87	4.51
Median Rooms	5.50	0.14	5.50	0.33
Rent/Income Ratio	0.19	0.60	0.19	0.03
Home Price/Income Ratio	3.67	5.44	3.69	3.03

Parenthood and moving, with older parents

Back Baseline



Parenthood and moving, with older parents

Back

Table:
ab:tab:appendix$_s ummary_s tats_A llPvNWeightedAverageOriginLevelsandPercentageChangesforMovers$:
$AllParentsvs.Non - Parents(Unadjusted)$

Variable	Parent Origin	Parent Change (%)	Non-P Origin	Non-P Change (%)
Local Wages / Income	63131.00	3.73	63732.02	5.43
Median Rooms	5.49	0.17	5.51	0.16
Rent/Income Ratio	0.19	0.37	0.19	0.60
Home Price/Income Ratio	3.65	3.43	3.66	5.71

Ownership and childbirth

Back No IDFE

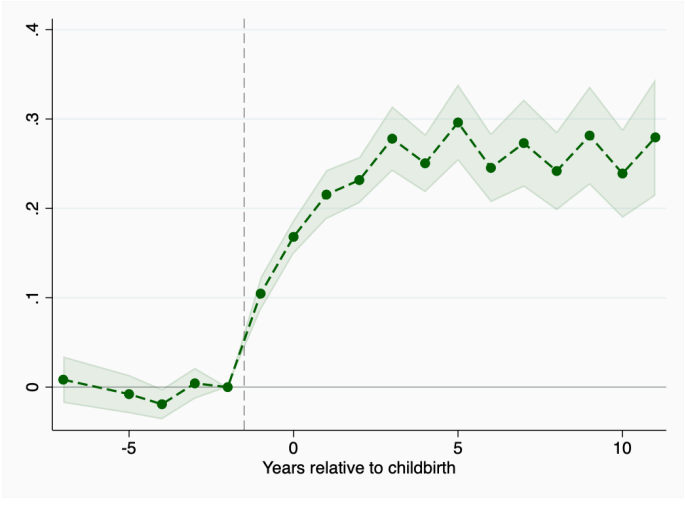


Figure: Homeownership on First Childbirth

Homeownership baseline means

Back

Table: Baseline Homeownership (weighted means)

	Non-Parents	Non-Parents	Non-Parents
ownhome	0.518	0.599	0.531
Observations	1882304	394867	2277171

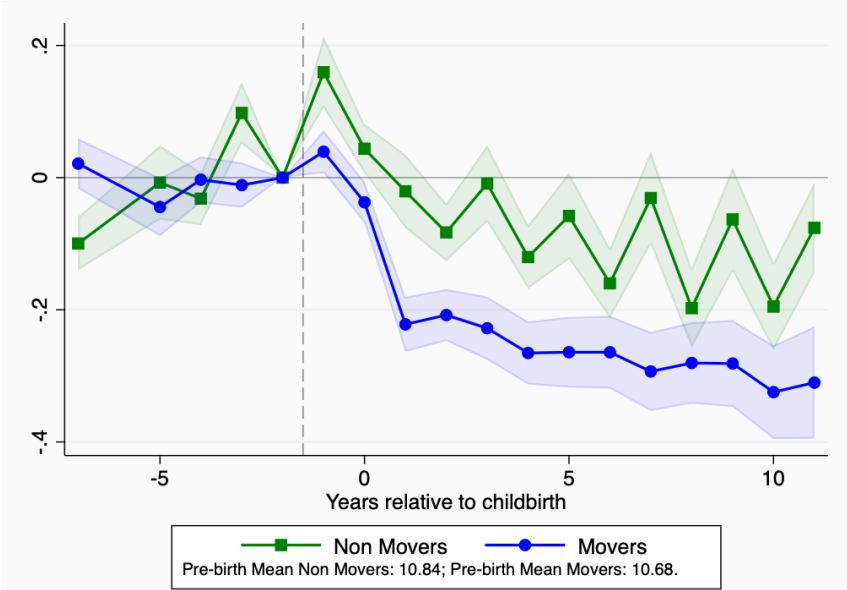
Metro Principal Status baseline statistics

Back

Table: Baseline Weighted Means by Population Group

	Non-Parents and New Parents	Full Sample
Lives in	0.540	0.526
Moved To	0.078	0.074
Left From	0.208	0.215
Observations	5915221	9056296

PSID: Income Trajectories (Movers vs Non-Movers)



HJB and KF on the BGP

Back

Let $\hat{z} \equiv e^{-\gamma t} z$ and $\hat{\Omega} = (i, a, n, a_n)$. On a BGP:

HJB between shocks

$$(\rho - (1-\sigma)\gamma)\, v(\hat{b}, \hat{h}, \hat{\Omega}) = \max_{\hat{c} \geq 0,\ \hat{h}^R \geq 0} \Big\{ u(\hat{c}, \chi \hat{h} + \hat{h}^R; n) + \frac{\partial v}{\partial \hat{b}}\, \dot{\hat{b}} - \gamma \hat{h}\, \frac{\partial v}{\partial \hat{h}} + \frac{\partial v}{\partial a} + \frac{\partial v}{\partial a_n} \Big\},$$

$$\dot{\hat{b}} = \hat{y}_i(a) + (q - \gamma)\hat{b} - \hat{c} - \hat{r}_i\, \hat{h}^R - (\delta + \tau_H)\, \hat{p}_i\, \hat{h}, \qquad \dot{\hat{h}} = -\gamma \hat{h},$$

$$\text{s.t.} \quad \hat{b} \geq -\theta_{\text{LTV}}\, \hat{p}_i\, \hat{h}, \qquad \hat{h}^R = 0 \text{ if } \hat{h} > 0.$$

KFE between shocks

$$0 = -\frac{\partial}{\partial \hat{b}} \Big(\phi\, \dot{\hat{b}} \Big) - \frac{\partial}{\partial \hat{h}} \Big(\phi\, (-\gamma \hat{h}) \Big) - \frac{\partial \phi}{\partial a} - \frac{\partial \phi}{\partial a_n}, \qquad \Big[\phi\, \dot{\hat{b}} \Big]_{\hat{b} = -\theta_{\text{LTV}}\, \hat{p}_i\, \hat{h}} = 0.$$

At shock ages (fertility $\to$ relocation $\to$ owner size), the hatted transitions: $s^f(\cdot)$, $s_l(\cdot)$, and the deterministic owner-size pushforward.

Details on Value functions and wealth at shock ages

Back

- **Immediately after choosing location** i', liquid wealth and owner-housing of a household

$$\tilde{b}_t^l(b,h,i,i') = b + \mathbb{I}(i \neq i')(1-\psi)p_{it}h,$$
$$\tilde{h}^l(h,i,i') = \mathbb{I}\{i' = i\}h$$

- After choosing location, choose owner housing. **Immediately after adjusting owner house size** to h', liquid wealth is

$$\tilde{b}_t^H(b,h,h',i) = b + \mathbb{I}\{h' \neq h\}[(1-\psi)p_{it}h - p_{it}h']$$

and then when chosing owner size,

$$\tilde{h}_t(\Omega) = \arg \max_{h' \in \mathcal{H}_t(b,h,i)} V_t\big(\tilde{b}_t^H(b,h,h',i), h', i, a, n, a_n\big)$$

The value of optimal owner-occupied housing choice is

$$V_t^H(\Omega) = V_t\big(\tilde{b}_t(\Omega; \tilde{h}_t(\Omega), \tilde{h}_t(\Omega), i, a, n, a_n\big).$$

Maturity and entry boundaries

Back

Child maturity (reset only). At $a_n = A_m$ (at the shock time), before fertility:

$$g_t^{\text{mat}}(\cdot,\, n', a'_n) \;=\; \mathbf{1}\{(n', a'_n) = (0,0)\} \sum_n \Big[\lim_{\iota \downarrow 0} g_{t-\iota}(\cdot,\, a-\iota,\, n,\, A_m) \Big].$$

Death and local estates. Mass exits at $a = A$. Local estates in city i:

$$B_i = \iint \big[b + (1-\psi)\, p_i\, h \big]\; g_{t^-}(b, h, i,\, a{=}A,\, \cdot)\; db\, dh.$$

Entry (city-level recycling). New adults at $a = 0$ start as renters with

$$b_0(i) = b_{\text{entry}} + \frac{B_i}{N_i^0}, \qquad h_0 = 0,$$

and we inject N_i^0 units of mass at $(b_0(i), h_0, i, 0, 0, 0)$.

References I

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