Monetary Transmission in a HANK Model with Housing and Rental Sectors

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Motivation

Recent period drew increased scrutiny to housing/rental market and effect of monetary policy.

- Limited empirical evidence base beyond house price and rent:price ratio.
- HANK literature not yet incorporated housing element.

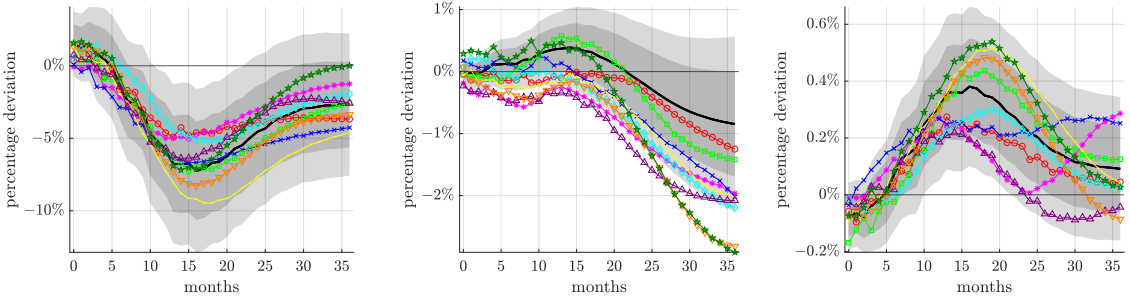
→ This paper: **HANK + housing + rental**

Contributions

1. Empirical results for monetary policy shock in the UK:
   - i **house prices are slow to fall** (hump-shaped), but magnitude is eventually large
   - ii **rents are stable** for 1-2 years, then fall
   - iii **sales fall is sluggish** (hump-shaped) for 1-2 years
2. Build upon canonical HANK model: housing tenure
   - renter / owner-occupier / **private landlord**
   - match to the data: house market targets + aggregate IRFs
   - i + ii + iii → **deviations from rational expectations**
3. Applications
   - Housing **market clearing**
   - **Frictions** (real v behavioural) & house price dynamics
   - Rental market structure: **private v commercial landlords**
   - Monetary policy response to **rental supply shock** [Not today]

Empirical Evidence

House prices: hump-shaped decline; rents: stable for at least year

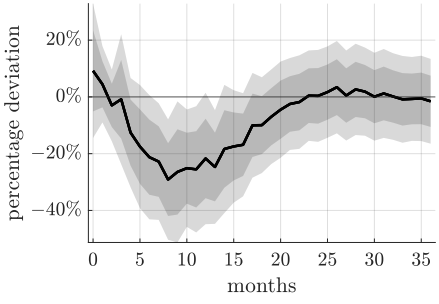


(A) House prices **(B)** Rents **(C)** Rent-to-price ratio

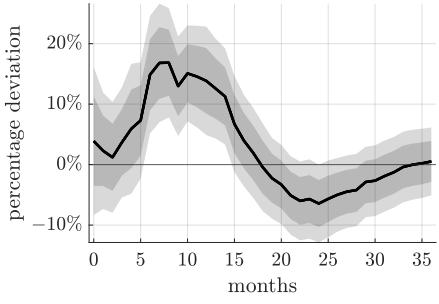
Figure IRFs to 1p.p. Bank Rate shock

- Estimate a monthly VAR from 1997-2023 [regions in colours, 2005-2023], with dummies for the Covid period. ▸ IRFs
- VAR with 7 variables: GDP, CPI core ex-rent, bank rate, mortgage spread, FTSE, house prices and rents
- Use target factor from Braun et al. [2024] as instrument for bank rate

Sales and stocks: reduced activity for more than a year



(A) Sales volume



(B) Stock of unsold houses

- p_h does not fall enough to maintain activity in housing market → not FIRE?

Model: HANK + housing + rental

Model: HANK and Housing

- HANK model, with 2 assets: net financial wealth and housing
  - → flats H_1 and houses H_2, $H_2 > H_1$, only flats can be rented
  - → renters r, owner occupiers oo, or landlords ll
  - → borrowing against your home(s) subject to LTV/LTI constraints
  - → sticky rental transitions with probability $\theta_r = 0.25$
  - → short-run analysis: fixed housing supply

- Housing market clearing conditions:
  - Housing: $\overline{H} = H_1(s_{r,t} + s_{ooF,t}) + H_2(s_{ooH,t} + s_{ll,t})$
  - Rental: $H_1 s_{r,t} = H_1 s_{ll1,t} + 2H_1 s_{ll2,t} + \overline{HA}$

Household's problem

- **Stage 1**: aggregate state χ; idiosyncratic labour productivity is $z = (z_1, z_2)$; and taste shock $\epsilon(h)$ are realised; housing transition h' is chosen

$$V^{(1)}(\chi, h', z, a) = \max_{\tilde{h}} \left[V^{(2)}(\chi, \tilde{h}, z, a) + \epsilon(\tilde{h}) - \eta(\tilde{h}) \right]$$

→ if we assume a Gumbel distribution for $\epsilon(h)$, then

$$Prob(\chi, h'|h, z, a) = \exp\left(\frac{V^{(2)}(\chi, h', z, a) - \eta(h')}{\alpha_z} \right) / \sum_{h'|h} \exp\left(\frac{V^{(2)}(\chi, h', z, a) - \eta(h')}{\alpha_z} \right)$$

- **Stage 2**: choice of consumption/savings

$$V^{(2)}(\chi, h', a, z) = \max_{a'} u(c, h', l) + \beta \mathbf{E}[V^{(1)}(\chi'|\chi, h', z'|z, a')]$$

subject to budget and borrowing constraints, with

$u(c, h, l) = \frac{(c^{1-\phi_h} x(h)^{\phi_h})^{1-\sigma_c}}{1-\sigma_c} - \phi_l \frac{l^{1+\psi_l}}{1+\psi_l}$, $x(h) = H(h)(1 + \omega_{oo} \mathbf{1}_{oo})$

Budget and borrowing constraints

$$a' + c + C_h(p_h, p_r, p_r^*, h') = (1 + r + \mathbf{1}_{a<0}\bar{r})a + zwl(1-\tau) + \Pi(z),$$
$$a' \geqslant \bar{a}(h', p_h, z, w, l)$$

Transition	$-C_h$	$\bar{a}$
Own H - Own H	$-\delta_h H_2$	$\min(a, \max(-\kappa_h p_h H_2, -\kappa_y y(z)))$
Own H - Own F	$-p_h(H_1 - H_2) - 2F - \delta_h H_1$	$\max(-\kappa_h p_h H_1, -\kappa_y y(z))$
Own H - Rent	$p_h H_2 - F - p_r^*$	0
Own H - LL	$-p_h H_1 - F + p_r^* - \delta_h(H_1 + H_2)$	$\max(-\kappa_h p_h(H_1 + H_2), -\kappa_y y(z) - \kappa_h H_1 p_h)$
Own F - Own F	$-\delta_h H_1$	$\min(a, \max(-\kappa_h p_h H_1, -\kappa_y y(z)))$
Own F - Own H	$-p_h(H_2 - H_1) - 2F - \delta_h H_2$	$\max(-\kappa_h p_h H_2, -\kappa_y y(z))$
Own F - Rent	$p_h H_1 - F - p_r^*$	0
Rent - Own F	$-p_h H_1 - F - \delta_h H_1$	$\max(-\kappa_h p_h H_1, -\kappa_y y(z)))$
Rent - Rent	$-p_{r,i}$	0
LL - Own H	$H_1 p_h - F - \delta_h H_2$	$\min(a + p_h H_1 - F, \max(-\kappa_h p_h H_2, -\kappa_y y(z)))$
LL - LL	$p_{r,i} - \delta_h(H_2 + H_1)$	$\min(a, \max(-\kappa_h p_h(H_1 + H_2), -\kappa_h p_h H_1 - \kappa_y y(z))$
LL - LL x2	$-H_1 p_h + 2p_r^* - F - \delta_h(H_2 + 2H_1)$	$\max(-\kappa_h p_h(2H_1 + H_2), -\kappa_h 2p_h H_1 - \kappa_y y(z))$
LL x2 - LL x2	$2p_{r,i} - \delta_h(H_2 + 2H_1)$	$\min(a, \max(-\kappa_h p_h(2H_1 + H_2), -\kappa_h 2p_h H_1 - \kappa_y y(z)))$
LL x2 - LL	$H_1 p_h + p_r^* - F - \delta_h(H_2 + H_1)$	$\min(a + H_1 p_h - F, \max(-\kappa_h p_h(H_1 + H_2), -\kappa_h p_h H_1 - \kappa_y y(z)))$

Deviation from Rational Expectations to match empirical IRFs

Evidence

- We allow households to simultaneously **overreact to current economic conditions** and **under-react to news about the future** (Kohlhas and Walther [2021])

$$\bar{f}_t(x_{t+k} - x_{ss}) = \frac{1}{1+\delta_x}\left(\delta_x \bar{f}_{t-1}[x_{t+k} - x_{ss}] + E_t^*[x_{t+k} - x_{ss}] - \gamma_x(x_t - x_{ss})\right)$$

- $\gamma_x < 0$: over-reaction to current conditions; $\delta_x > 0$: under-reaction to news
  - $\gamma_x = 0, \delta_x = 0 \rightarrow RE$
  - $\gamma_x = 0, \delta_x > 0 \rightarrow$ sticky expectations
  - $\gamma_x < 0, \delta_x = 0 \approx$ extrapolative/diagnostic

- We allow for γ, δ to be different for house prices vs other macro aggregates
  - find **under-reaction to news** for both: $\delta_x, \delta_{ph} > 0$
  - but **no over-reaction to current conditions for house prices** ($\gamma_{ph} \approx 0, \gamma_x < 0$)

Rest of the Model

- Rest of the model is standard: Price/Wage PC, Fiscal rule, Taylor rule...
- Solved in sequence space with upper envelope EGM (Iskhakov et al. [2017])
- Generalised deviation from Rational Expectations follows Bardóczy and Guerreiro [2025] framework.
- Calibrate to hit key moments on wealth, income risk, tenure shares, iMPC's...

Calibration

▸ More Cal.

1. Estimated labour income process with transitory and persistent components
2. Internally calibrated parameters

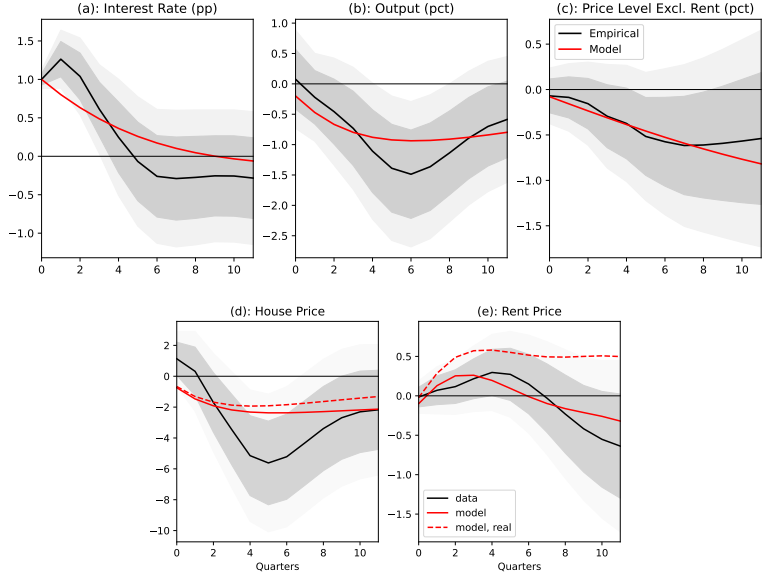
Targeted Moment	Model	Data	Parameter	Source
Ann. Debt to GDP	0.63	0.65	β	ONS
Share of Renters	0.33	0.33	$\phi_h, \omega_{oo}, p_{r,ss}$	EHS (97-23)
Share of Flat Owners	0.10	0.10	$\phi_h, \omega_{oo}, p_{r,ss}$	EHS (97-23)
Share of Landlords	0.06	0.06	$\phi_h, \omega_{oo}, p_{r,ss}$	WAS (08-20)
Annual rate $oo \rightarrow r$	0.01	0.01	η_m	EHS (97-23)

3. Untargeted Moments:

Moment	Model	Data	Source
Housing Wealth to Financial Net Worth	8.0	7.0	WAS (08-20)
Top 10 pct. Total Wealth Share	0.31	0.48	WAS (08-20)
Share of Homeowners with Mortgage	0.54	0.53	EHS (97-23)
Share of Landlords with Mortgage	0.49	0.57	WAS (07-20)
Avg Rent to Renter Disposable Income	0.28	0.33	EHS (97-23)

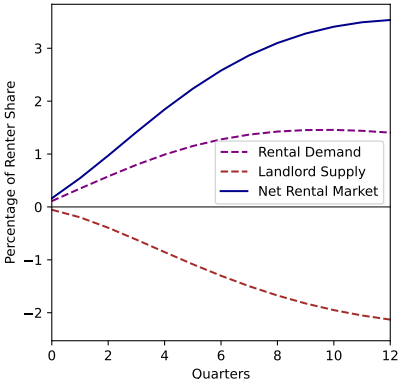
IRF Matching

▸ Parameters ▸ Alt. Expectations

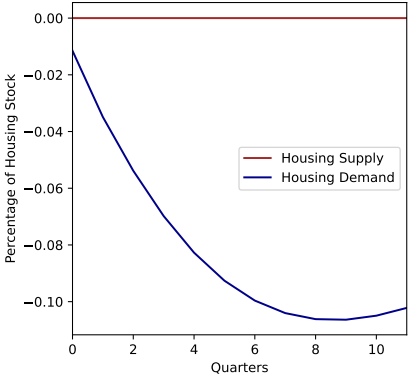


Model Applications

Housing Market Clearing: Partial Equilibrium



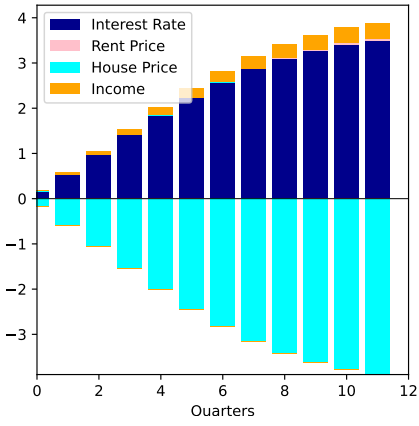
(A) Net demand: Rental Market



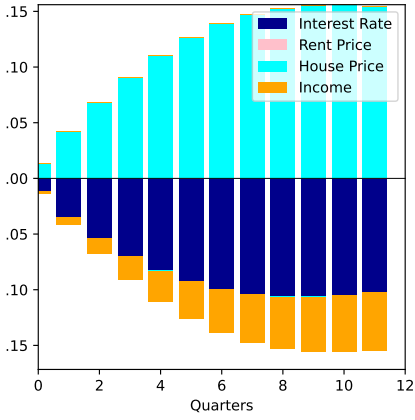
(B) Net demand: Housing Market

- Excess demand in the rental market and excess supply in the housing market.

Housing Market Clearing: General Equilibrium



(A) Net demand: Rental Market

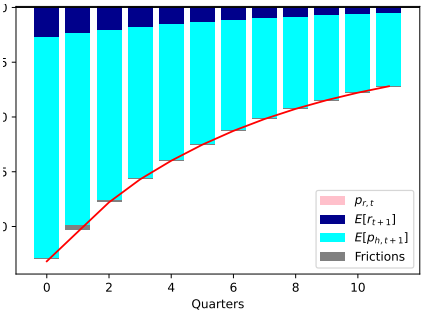


(B) Net demand: Housing Market

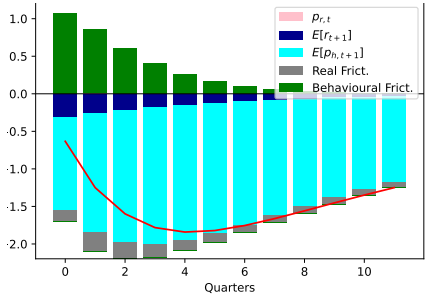
- $\uparrow r \rightarrow$ house prices react to close housing and rental markets; rental prices do not have a big effect ▸ Elasticities

Frictions: House Price Path

Model Quants.



(A) Rational Expectations



(B) Deviation from FIRE

$$p_{h,t} = p_{r,t} + E_t\left[\frac{p_{h,t+1}}{1 + r_{t+1}}\right] + \text{frictions}$$

- Behavioural frictions are key
- Lumpiness and constraints pull down on house price, larger when elasticity is higher.

Frictions: Frictionless Benchmark

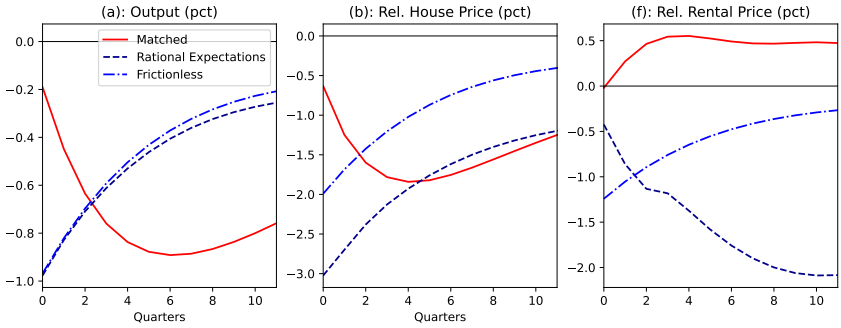


Figure IRFs with/without frictions

- Behavioural frictions push up on rental price
- Rat Exp. HANK model has similar dynamics to frictionless benchmark.
  - Frictionless benchmark: RANK, no sticky rental contracts, no transaction costs, no borrowing constraints, no lumpiness.

Housing → Monetary Policy

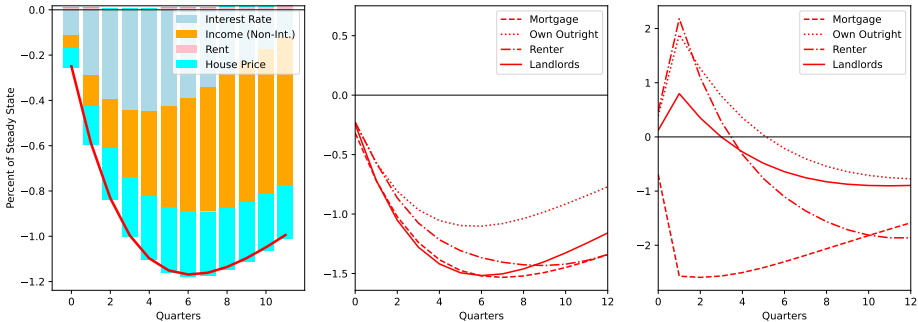
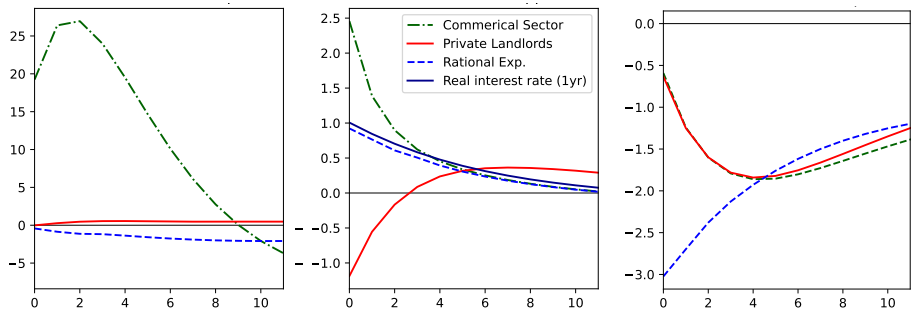


Figure Consumption Channels and by Housing Tenure

- Around 25% of transmission at the through of p_h.
- Winners and losers
- Landlords hit as hard(er) as renters, even though much wealthier (HTM)

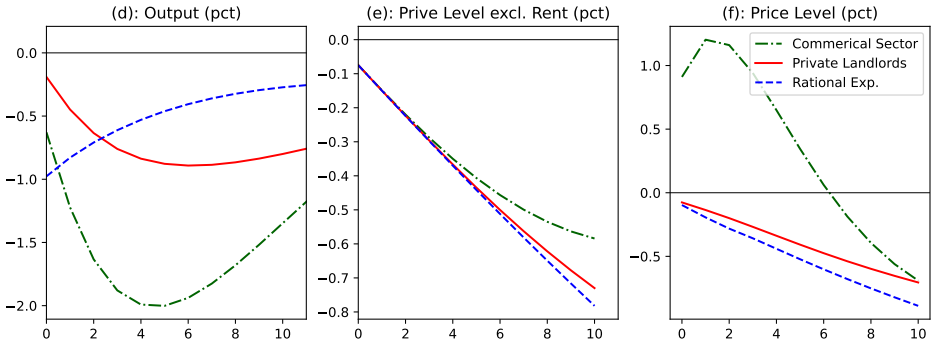
Rental Market Structure: Unconstrained vs private landlords



(A) Rents **(B)** Rental yield **(C)** House prices

- Commercial sector borrows from banks and purchases rental housing $H_{CR,t}$. ▸ Pricing
- Rents have limited impact on the (non-rental) housing market
- Higher pass-through of interest rates to rents → big trade-offs for monetary policy

Rental Market Structure: Unconstrained vs private landlords



- Much higher Sacrifice ratio in commerical sector case (green dashed line).
  - Two to three times higher.
- Private landlords mititgate this but best is no behavioural frictions

Conclusion

- We've added to the evidence base on monetary policy and housing markets
  - Large slow house price response, flat rental prices
  - Adjustment through volumes
- Housing a potentially big channel in HANK models, creating winners and losers
- Probed housing market clearing in rental market with private landlords
  - Behavioural frictions and house price elasticity key
  - Private landlords losers in a monetary adjustment but beneficial to monetary policy
- Supply determined nature of housing might push policymakers to look past shocks to rental or housing sector. ▸ CPI target.

Appendix

IRFs for baseline VAR

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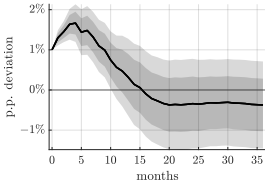
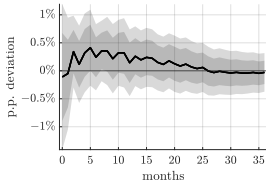
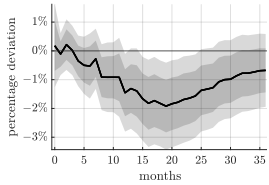


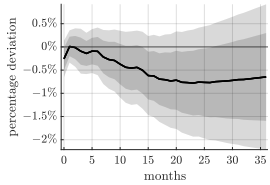
(A) Bank Rate



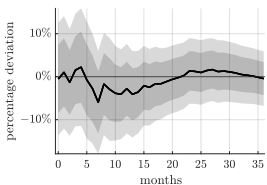
(B) Mortgage spread



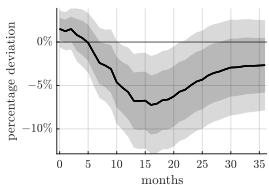
(C) GDP



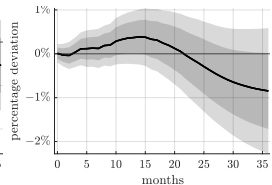
(D) CPI core



(E) FTSE

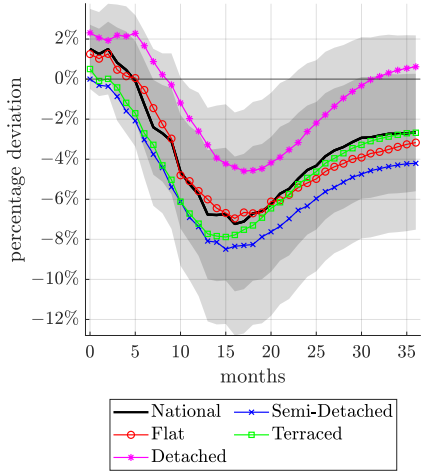


(F) House prices



(G) Rent prices

Dwelling types: similar co-movement



→ prices across regions and types react in the same way → single p_h

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External Calibration

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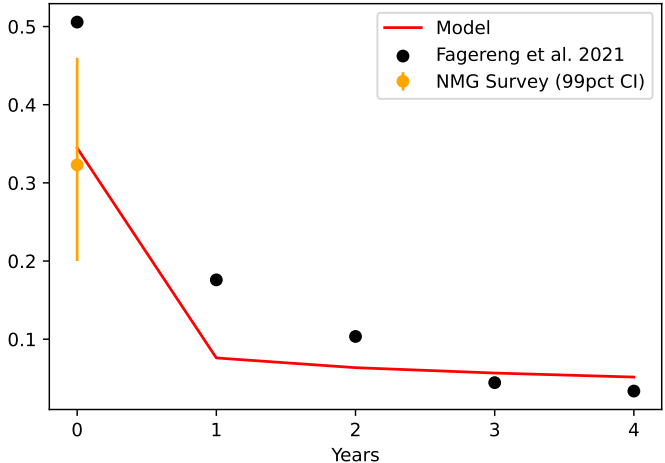
Table Externally calibrated parameters

Parameter	Value	Source
Frisch	0.5	Auclert et al. [2020]
EIS	0.5	
Steady State Markup	1.06	Auclert et al. [2020]
Borrowing wedge $\bar{r}(ann)$	0.0126	(avg 97-19 of 2yr 75pct)
Transaction Cost	$0.02p_{h,ss}$	Halifax
$\frac{p_{h,ss}}{\bar{y}}$	6.3	Avg 97-23 ONS; $\bar{H}$
Loan to value max κ_h	0.90	PSD 90 pctile. FTB
Loan to income max κ_y	4.5	PSD 90 pctile. FTB
Rental price adj. prob θ_r	0.25	1 year contract
Housing Maintenance (ann) δ_h	0.0009	ONS CPI-H
Taste shock scaler α_z	0.15	Iskhakov et al. [2017]


Model
Fagereng et al. 2021
NMG Survey (99pct CI)
0.5
0.4
0.3
0.2
0.1
0
1
2
3
4
Years

IRF Matching Parameters

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Table IRF Matched Parameters

Parameter	Rational Exp.	Sticky	Baseline
Price Philips Curve κ_p	0.003	0.5	0.01
Wage Philips Curve κ_w	0.28	0.5	0.004
Fiscal rules (debt stab.)	0.014	0.08	0.12
Taylor rule $\left(\phi_\pi, \phi_y, \rho_m\right)$	(2.5, 0.17, 0.93)	(2.5, 0.0, 0.92)	(1.01, 0.0, 0.87)
Price update prob. $\frac{1}{1+\delta_x}$	1.0	0.05	0.13
House price update prob. $\frac{1}{1+\delta_{ph}}$	1.0	0.09	0.36
Price extrapolation γ_x	0.0	0.0	-0.42
House price extrapolation γ_{ph}	0.0	0.0	0.02

IRF Matching (Comparison)

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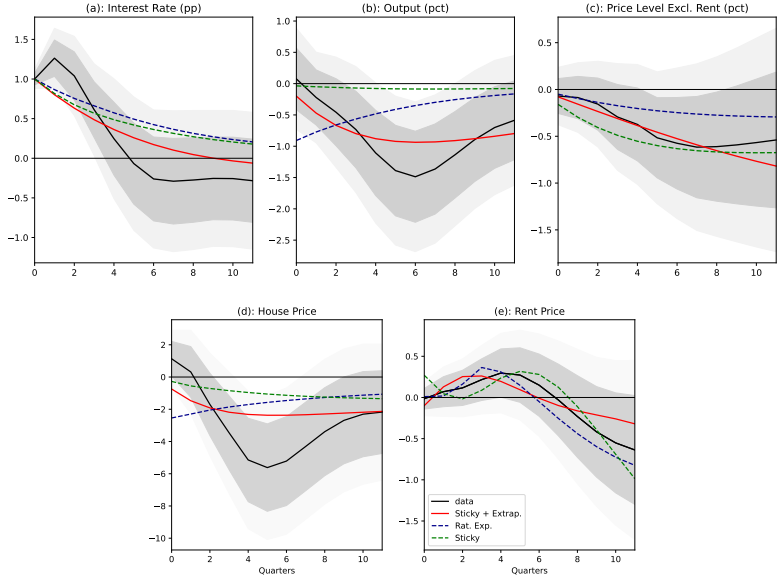

Commercial Sector Pricing

- Commercial sector can borrow from bank and purchase rental housing.
- Subject to fixed costs to make price same in steady state and indifferent too entry.
- Same contract constraints as private landlords.
- Any profits (unexpected capital gains on housing) distributed with aggregate dividends
- Sets marginal price as follows.

$$p_{r,t} = E_t\left[\frac{\epsilon_r}{\epsilon_r - 1}\left(\delta_{hf} + \frac{p_{h,t}}{v_{1,t}} - \theta_r \frac{v_{2,t}}{v_{1,t}}\right)\right],$$

where $v_{1,t}$, $v_{2,t}$ are the usual forwarding looking terms in the solution of firms' problem subject to Calvo pricing.

$$H_1 s_{r,t} = H_1 s_{ll1,t} + 2H_1 s_{ll2,t} + \overline{HA} + \underbrace{H_{CR,t}}_{\text{Com. Supply}}$$

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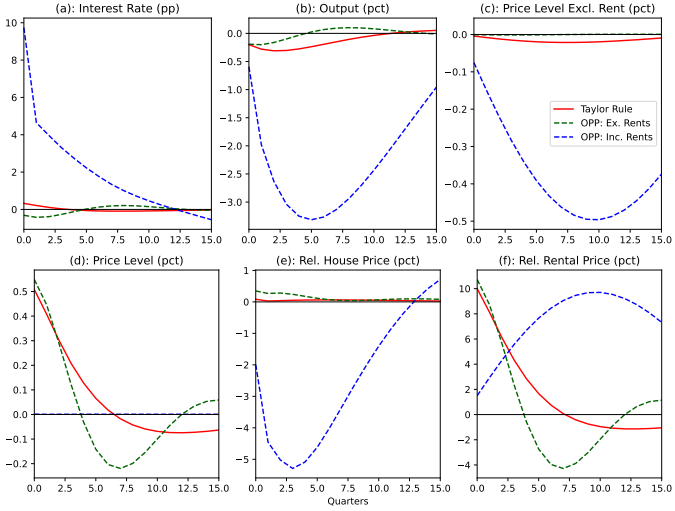
Policy Response to Rental Market Shock



- Policy Maker targets a loss function of minimising $L_x = \sum_{t=0}^{20} (\pi_{t,x})^2$

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Empircal evidence on expectations

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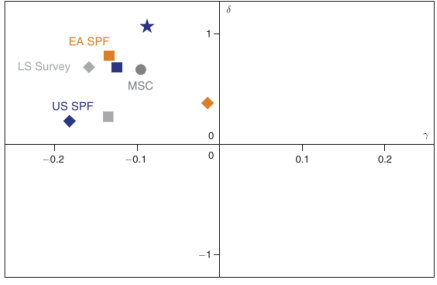
Table Michigan Survey

	Forecast Error		
	No extrap.	Extrap	IV
γ_{p_h}	-	-0.02	-0.03
	-	(0.05)	(0.04)
δ_{p_h}	1.45	1.46	1.94
	(0.26)	(0.32)	(1.39)
Observations	68	68	68
R^2	0.46	0.46	0.41

Notes: Tables presents for regressions of the form of Kohlhas and Walther [2021] for real log house price expectations in the Michigan Survey:

$$p_{t+4} - f_{t+1,t+4} = \gamma_{p_h} p_t + \delta_{p_h}(f_{t+1,t+4} - f_{t,t+3}) + \epsilon_t.$$

Figure Kohlhas and Walther [2021]



Sales Volumes (model)

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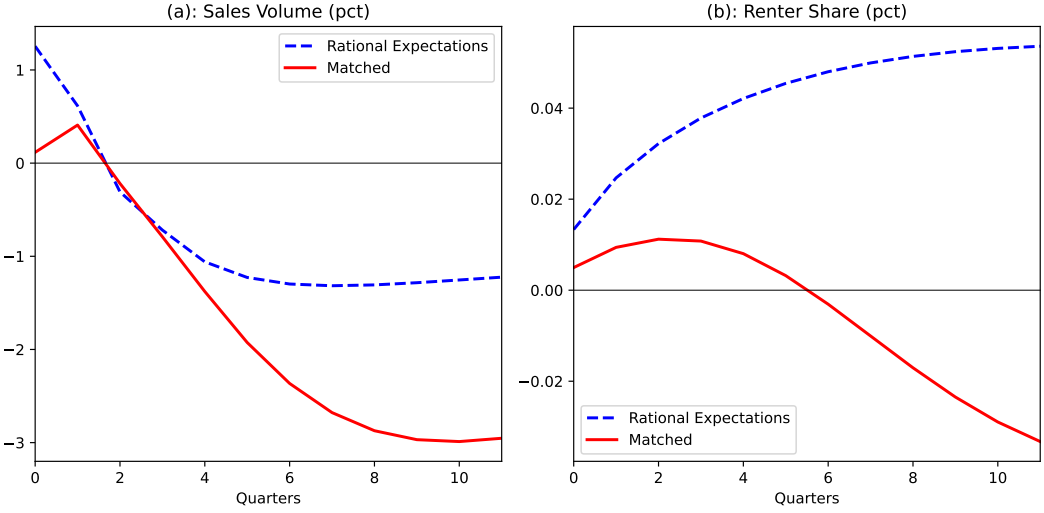


Figure Further IRFs

Housing Market Clearing: Elasticities

Back

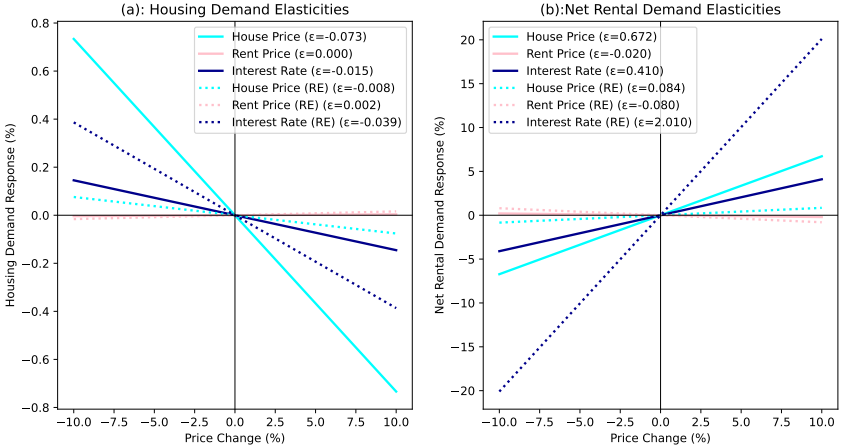
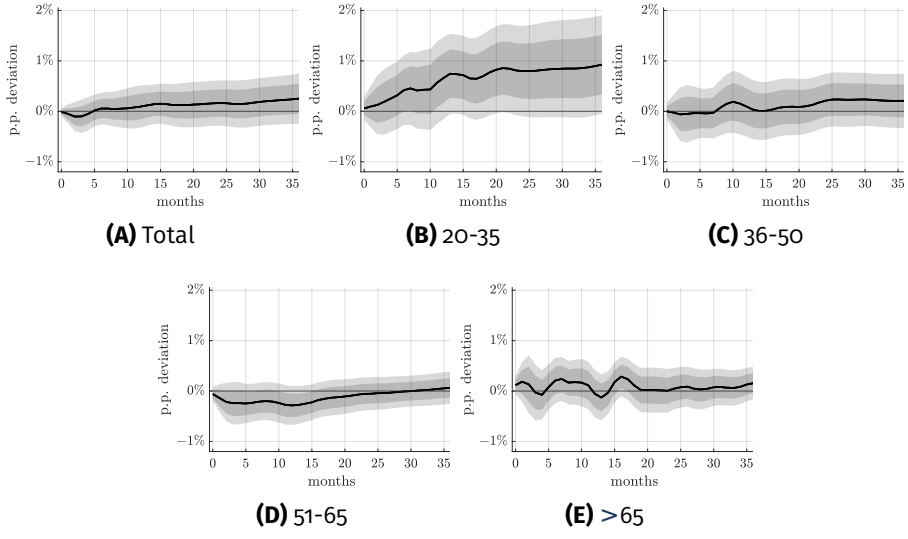


Figure Housing Market Elasticities

- Little spillovers from rental price to broader housing market
- Behavioural frictions sharpen house price elasticity

Renter Share



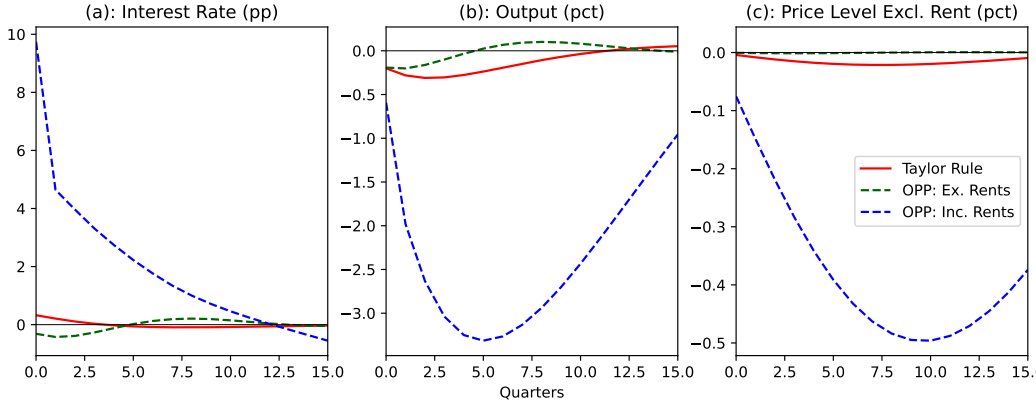
(A) Total **(B)** 20-35 **(C)** 36-50

(D) 51-65 **(E)** >65

Figure Share of renters - total and by age

Rental Market Shock: Targetting CPI with(out) rents

More IRFs Back



- Rental Housing supply shock that increases rents by 10% on impact
- Follow Barnichon and Mesters [2023] with policy makers minimising a loss function of $L_x = \sum_{t=0}^{20} (\pi_{t,x})^2$
- Targetting CPI with rents after housing shock leads to (too much) output volatility

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