Flipping Houses in a Decentralized Market

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Abstract

How does intermediation in housing market determines house price distribution, trade volume, and welfare? I study *flipping houses* - fast buying and reselling houses, which becomes more prevalent in recent years. While more flipping increases market thickness, it also involves intermediaries holding housing asset instead of households. Which effect dominates for welfare? To answer these questions, I develop a search model with two-sided heterogeneity in inventory and housing asset valuation, where households trade houses with each other or with flippers. Household types evolve stochastically and trade is decentralized. Using universe of administrative transaction data from Ireland, I document a steady increase in house prices, trade volume, and flipped transactions between 2012 and 2022. In particular, I find that number of flipped transactions doubled. Through a calibrated model, I use an increase in mass of flippers to match such change. This led to a 0.59% decrease in average house prices, decrease of households welfare by 0.08% and a 1% increase in non-owners welfare. Misallocation of housing due to search frictions decreased mainly among non-owners. Trade volume increased by 1.7% where between household trade is crowded out by trade with flippers. Subsequently, I analyze the impact of a 9% tax on flippers, similar to the pre-2011 policy in Ireland. I find negative welfare effects of non-owner households and big reduction in flipped transactions.

JEL Codes: D83, E21, G12, R3.

Keywords: Housing , Search, Liquidity.

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1 Introduction

In the housing market, intermediation increases market thickness but incurs welfare costs due to asset holding by intermediary.
In housing market such role is played voluntarily by flippers.
Those agents buy and sell houses during short periods of time.
The role of flippers in the housing market and their share of all trades have been growing in recent decades[1].

Market for houses exhibits search friction and trade is facilitated bilaterally.
How those are intertwined in case of housing market and what are the effects of flippers on prices, quantities and welfare.
Is it welfare increasing to have improved market thickness at cost of hold up?
Housing is the biggest asset category for households accounting for over 70% of wealth in developed economies[2].
How does house flipping affect house price distribution, trade volume, and liquidity in the housing market?
Should we tax them or subsidize them? This paper studies role flippers in intermediation in housing market.
To answer these questions, I develop a search model with two-sided heterogeneity in inventory and housing asset valuation, where households trade houses with each other or with flippers.
Household types evolve stochastically and trade is decentralized.

Using universe of administrative transaction data from Ireland, I document a steady increase in house prices, trade volume, and flipped transactions from 2012 to 2021.
Average transacted price increased by 76%[3].
Moreover the number of flipped transactions nearly doubled.
Through a calibrated model, I find that this increase led to a 0.59% decrease in average house prices and a 3% reduction in price variance.
Misallocation of housing due to search frictions decreased mainly among non-owners, while trade volume increased by 7%.

[1] add reference US and third country
[2] find in SCF for US and in HFCS for Ireland
[3] as number of annual consumption- important relative measure in case of our model- it increased by 47%

Subsequently, I analyze the impact of a 9% tax on flippers, similar to the pre-2011 policy in Ireland. I find small negative welfare effects of non-owner households.

When allowing additionally for trade in housing asset between households,

Measurement of Flipping Following the existing literature Bayer et al. (2020) and Depken et al. (2009) Lee and Choi (2011) [4], we define flipping activity as the buying and selling of houses within short periods, specifically within two years[5].
In appendix we apply alternative definition of flipping set at 1 and 4 year mark.
In Ireland, between 2012 and 2021, a quarter of all multiple trades were flipped trades. During this period, both the fraction of flipped houses and house prices doubled[6]. This substantial increase highlights the significant role of flippers in the housing market, often associated with quality improvements to the properties they trade, while important we ignore quality improvement aspect for now.

Theory Computation Results

Literature review House flipping was studied Bayer et al. (2020) and Depken et al. (2009), Lee and Choi (2011), Gavazza (2016) but not always as intermediation in housing market. Most papers look at price effects and found that ...

Intermediation via bilateral trade (with search) was studied by Duffie et al. (2005),Hugonnier et al. (2020), Weill (2020), Lagos and Rocheteau (2009), Üslü (2019), Krainer and LeRoy (2002), Allen et al. (2019). I use insights from those papers, especially first two papers influenced the way I model household vs household trade and shed light into heterogeneity in valuations (called types in my model).
Extending their insights on behavior at margin help me characterize better patters and mottives for trade in my model.
Best to my knowledge this paper is the first one to combine continuous time models from

[4] add references

[5] In roughly x% of those transactions house underwent quality improvements.
Note that definition of flipping doesn't require such change in quality making flipping activity primarily arbitrate.

[6] Details of changes in prices and fractions of flipped houses and multiple trades over time are in Table 1 in Appendix xxx

that sequence of papers on OTC markets with threshold equilibria (reservation values called here cutoffs).

Price distribution was studied by ...Piazzesi et al. (2020), Rekkas et al. (2020), Diamond and Diamond (2024), Head et al. (2014), Üslü (2019)

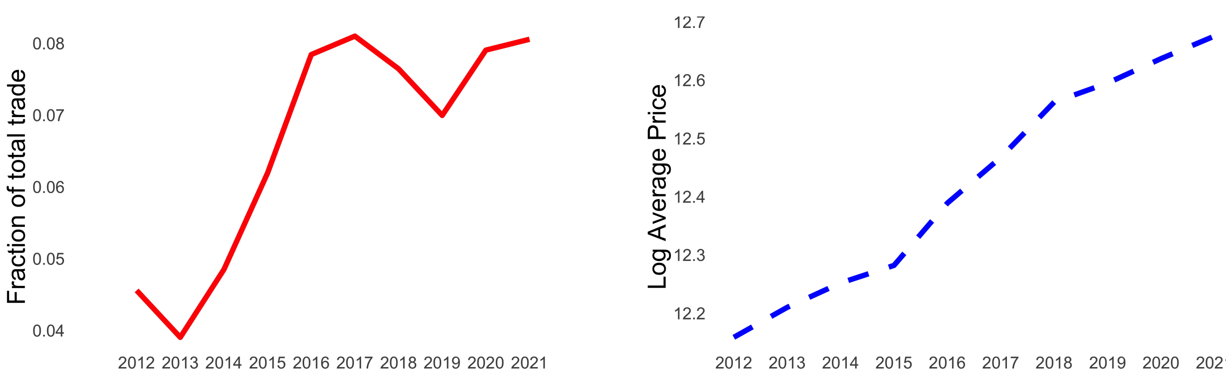
Homeownership was studied by ... Acolin et al. (2016), Sodini et al. (2023), Anenberg and Ringo (2022). I use the same data set as Mitman, Peter, Piazessi, Schneider focusing on one country instead of cross country comparison.

Taxation of housing İmrohoroğlu et al. (2018), Sommer and Sullivan (2018), Kopczuk and Munroe (2015),

Figure 1: Prices and Quantities

(a) Flipping in Ireland 2012-2022

(b) Average Prices



Note:

Outline Section 2 introduces a toy model of the housing market, where households trade exclusively with flippers.
The model highlights the role of flippers as intermediaries and trade off between liquidity and hold up.
Section 3 presents empirical findings related to prices, returns, and patterns of trade and flipping in Ireland, using comprehensive transaction data and cross-sectional household surveys.
Section 4 extends the model to include both household-to-household and household-to-flipper trades, and calibrates the model.
That section provides a more detailed simulation of market dynamics, incorporating heterogeneity among agents and varying meeting rates.
Section 5 discusses the counterfactual exercises and policy experiments.

The section first analyzes the effects of increased flipping activity on market dynamics, examining changes in prices, quantities, and welfare.
Additionally, it explores the implications of a change in search rate equivalent to increasing flipping activity, comparing these scenarios to understand their differential impacts.
The policy analysis involves quantifying the impact of a 9% sales tax on flippers, a policy similar to the pre-2011 tax regime in Ireland, and evaluates its effects on market outcomes and welfare.
Section 6 provides additional robustness checks, sensitivity analyses, and data validation for the model, ensuring the reliability and applicability of the findings.
Finally, Section 7 concludes by summarizing the key results and discussing the broader implications of the study for housing market policy and future research directions.
All proofs, derivations, and additional robustness results are included in the Appendix.

2 Toy Model

Household with Flipper trade (no Household with Household trade allowed)

Environment. Economy is populated by measure 1 of households and mass f of flippers.
Time is continuous and agents are infinitely lived.
There are two goods : nonstorable consumption good c, indivisible housing asset q.
Houses are identical and their supply is fixed at s.
There is neither production of houses, nor deterioration of housing supply.
Both households and flippers discount future with common rate r.
Households and flippers trade houses for consumption good.
They trade houses for units of consumption good to maximize their utilities.
All agents have risk neutral preferences.
This implies that agents will have $q \in \{0, 1\}$ of houses.
Trade in houses is decentralized, meetings are random.
For now trade is restricted to flipper and household; and household and flipper only.
Trade between households is prohibited.
One-on-one meetings between interested parties arrive with Poisson intensity λ.
If a meeting happens flipper (acting as buyer or seller) proposes a price.
The household accepts or rejects the offer.
If offer is accepted price is paid, asset changes owners and subperiod ends. Meetings between one specific household and individual flipper have a.s. zero chances to repeat in

future.

Exact timing of discrete version of this dynamic continuous time game can be find in in Appendix.

Households. Households have heterogenous types δ.
Deltas capture how much agents value owning a house. Those δ dividends from owning a house are non-tradable and evolve stochastically.
Household without a house and all flippers has zero flow utility.
Household with a house enjoys dividends δ.
Types come from fixed distribution with cumulative distribution function $G(\cdot)$. Assume that $G(\cdot)$ has compact support $[0, \bar{\delta}]$[7].
Distribution $G(\cdot)$ is public knowledge.
Valuations are private to households, in particular flippers don't know individual household's valuation.
With Poisson intensity γ type changes and it is redrawn from distribution $G(\cdot)$.

Flippers. Flippers have zero flow utility from owning (or not owning) an asset.
Their only role is to facilitate trade.
They do it in a way that they are the only way households can buy or sell houses.
Their only action is to propose a price in billateral meeting.
By private information assumption about types they can not condition terms of trade on type δ of household they trade with.

Strategies. I focus on history independent (no dependence on history of past realizations of λ, γ).
Flipper with a house $q = 1$ proposes a ***bid*** price P_1, one without a house $q = 0$ proposes a ***ask*** price P_1.
Household (q, δ) contingent on successful meeting flipper with opposite asset position $1 - q$ decides to accept of reject relevant price offer P_{1-q}.
Across all households this decision can be characterized by cutoff $\delta^*_q(P_{1-q})$. This reserva-

[7] Assume uniform distribution on $[0, 1]$: $G(\delta) = \delta$ and $\bar{\delta} = 1$

tion value characterizes household with q houses which is indifferent between accepting and rejecting flipper's offer P_{1-q}.
Household will buy an asset if he does not have one and his $\delta \geq \delta_0^*(P_1)$ and sell asset if she has one and $\delta \leq \delta_1^*(P_0)$.
We break ties by making agents at cutoffs to trade in equilibrium. Payments follows and house changes hands.

2.1 Equilibrium

Definition. Stationary, symmetric Markov Perfect Equilibrium with cutoffs consists of: cumulative distribution of households $H(q,\delta)$, fraction of flippers $F(q)$ for each $q \in \{0,1\}$, two prices : P_0 proposed by flipper-buyer and P_1 proposed by flipper with a house; cuttoffs $\delta_0^*(\cdot)$ for households buying a house and $\delta_1^*(\cdot)$ for households without a house, value functions for flippers $W(q)$ and for households $V(q,\delta)$.

Definition 1 (Stationary, Symmetric Markov Perfect Equilibrium with Cutoffs)**.** *is:*

1. *distributions :* $H : (q,\delta) \to \mathbb{R}$*,* $F : (q) \to \mathbb{R}$
2. *value functions* $V : (q,\delta) \to \mathbb{R}$*,* $W : (q) \to \mathbb{R}$
3. *decision rules: cuttoffs* $\delta_q^* : (\cdot) \to \mathbb{R}, q \in \{0,1\}$*, prices* $P_q \in \mathbb{R}_+, q \in \{0,1\}$

- *Given prices P.: value functions V and cutoffs* $\delta_\cdot^*$ *solve household problem (given by HJB equation)*
- *Given cutoffs* $\delta_\cdot^*$*: value functions W and prices P. solve flipper problem (given by HJB equations)*
- *Low of motions hold*
- *Accounting hold*

In short, I will call this equilibrium the stationary equilibrium.
First I will describe flipper's problem - the only agent making decision (price offer), households problems and to close a model stationary distributions as last.

Flipper's problem. Flipper without a house has 0 flow utility.
With rate λ randomly matches households buyers from probability distribution $dH(1,\delta)$.
Her decision is to pick a price P_0, taking into account cutoff $\delta_1^*(\cdot)$ and its effect on which fraction of households she trades with. Thus overall meeting rate is equal to $\lambda \int_0^{\delta_1^*(P_0)} dH(1,\delta)$.
If meeting happens and trade follows, she pays P_0 and becomes an owner.
In equilibrium this problem looks in following way:

$$rW(0) = \max_{P_0} \lambda \int_0^{\delta_1^*(P_0)} [-P_0 + W(1) - W(0)] dH(1,\delta) \tag{1}$$

Flipper with a house has 0 flow, proposes a price P_1 and meets randomly at rate λ households without a house from distribution $dH(0,\delta)$ taking $\delta_1^*(\cdot)$ into account.
When meeting succeeds and offer is accepted, she gets paid P_1 and becomes non owner:

$$rW(1) = \max_{P_1} \lambda \int_{\delta_0^*(P_1)}^1 [P_1 + W(0) - W(1)] dH(0,\delta) \tag{2}$$

Household's problem. Each household derives value from three things: flow utility, shocks to preferences and trade surplus.
Buyer: Household without a house with type δ has 0 flow utility.
It can be hit by a preference shock which arrives at rate γ.
It changes it's current valuation from δ to δ' drawn from distribution G.
With intensity λ meets with *a* flipper.
Household will meet with a flipper with a house with rate $\lambda F(1)$.
Trade will follows whenever there is double coincidence of wants.
If there are gains from trade household pays price P_1 and becomes an owner.

$$rV(0,\delta) = \underbrace{\gamma \int_0^1 [V(0,\delta') - V(0,\delta)] dG(\delta')}_{\textbf{change of type}} + \underbrace{\lambda F(1) \cdot \mathbb{1}[\delta \geq \delta_0(P_1)][-P_1 + V(1,\delta) - V(0,\delta)]}_{\textbf{HH vs F trade surplus}} \tag{3}$$

Seller: In similar way, homeowner household with type δ gets: flow utility δ, shock to type arrives at γ rate and trade opportunity arrives with one-on-one rate λ.

If trade is benefitial for seller he gets paid P_0 and becomes non owner.

$$rV(1,\delta) = \underbrace{\delta}_{\textbf{flow}} + \underbrace{\gamma \int_0^1 [V(1,\delta') - V(1,\delta)]dG(\delta')}_{\textbf{change of type}} + \underbrace{\lambda F(0) \cdot \mathbb{1}[\delta \leq \delta_1(P_0)][P_0 + V(0,\delta) - V(1,\delta)]}_{\textbf{HH vs F trade surplus}} \tag{4}$$

Each household value function problem can be seen as asset pricing with instantaneous return from investing $V(q,\delta)$ at rate r on left hand side and with three sources of dividend: flow utility, change in state and in benefit from trade.
Note that there is no capital gain due to stationarity of our problems.

Accountings Households and flippers who own a house hold all of s houses:

$$\int_0^{\bar{\delta}} dH(1,\delta) + F(1) = s \tag{5}$$

For any δ sum of all households without a house and below δ and households with a house and below δ has to be equal corresponding level of cdf of type $G(\delta)$:

$$\int_0^{\delta} dH(0,\delta) + \int_0^{\delta} dH(1,\delta) = G(\delta) \quad \forall \delta \in [0,\bar{\delta}] \tag{6}$$

Sum of fraction of flippers without a house $F(0)$ and wit $F(1)$ is equal f

$$F(0) + F(1) = f \tag{7}$$

Law of Motion In stationary equilibrium inflow and outflows to both homeownership and non-ownership both for households and flippers has to balance.
Trade and change in evolution of types generate those flows.
Let's focus on inflows and outflows to $[0,\delta]$ taking into account position of δ vs cutoffs δ_0^*, δ_1^*.

Homeownership (inflow and outflow to $[0,\delta], q = 1$)

$$\underbrace{\lambda F(1)\int_{\delta_0^*}^{\max\{\delta,\delta_0^*\}} dH(0,\delta')}_{\text{inflow from trade}} + \underbrace{\gamma G(\delta)\int_{\delta}^{1} dH(1,\delta')}_{\text{inflow from change of type from}[\delta,1]} = \tag{8}$$

$$= \underbrace{\lambda F(0)\int_{0}^{\min\{\delta,\delta_1^*\}} dH(1,\delta')}_{\text{outflow from trade}} + \underbrace{\gamma(1-G(\delta))\int_{0}^{\delta} dH(1,\delta')}_{\text{outflow from change of type to}[\delta,1]} \tag{9}$$

Inflows to homeownership comes from buying houses by households and change in valuations.

If first term is positive (trade happens) if δ is high enough such that household who don't own a house are willing to trade (their valuation is between δ_0^* and δ) and trade will happen with intensity $\lambda F(1)$. Second inflow to $[0,\delta]$ is proportional to mass of household who are owners and are above δ and with intensity γ are hit with taste shock and redraw valuation to be below δ which happens with probability $G(\delta)$.

Outflows from homeownership comes from selling houses by households and change in valuation.

Trade happens for low enough valuations (below or at δ_1^*), mass of interested households equal to integral and rate at which trade happens is equal to $\lambda F(0)$.

Second outflow from $[0,\delta]$ is proportional to mass of household who are non-owners and are below δ and with intensity γ are hit with taste shock and redraw valuation to be above δ which happens with probability $1 - G(\delta)$.

In similar way we can derive flows to and from non ownership by households.

Not owning (inflow and outflow to $[0,\delta], q = 0$)

$$\underbrace{\lambda F(0)\int_{0}^{\min\{\delta,\delta_1^*\}} dH(1,\delta')}_{\text{inflow from trade}} + \underbrace{\gamma G(\delta)\int_{\delta}^{1} dH(0,\delta')}_{\text{inflow from change of type from}[\delta,1]} =$$

$$= \underbrace{\lambda F(1)\int_{0}^{\max\{\delta,\delta_0^*\}} dH(0,\delta')}_{\text{outflow from trade}} + \underbrace{\gamma(1-G(\delta))\int_{0}^{\delta} dH(0,\delta')}_{\text{outflow from change of type to}[\delta,1]}$$

Using equations above we can derive equilibrium balance of trade for flippers. It equates a rate of trade of flippers buying and selling:

$$\lambda F(1) \int_{\delta_0^*}^{\bar{\delta}} dH(0,\delta) = \lambda F(0) \int_0^{\delta_1^*} dH(1,\delta) \tag{10}$$

Prices are such that agent at the cutoff is indifferent between trading and not trading, i.e. in equilibrium:

$$P_0 = V(1, \delta_1^*(P_0)) - V(0, \delta_1^*(P_0)) \tag{11}$$

$$P_1 = V(1, \delta_0^*(P_1)) - V(0, \delta_0^*(P_1)) \tag{12}$$

2.2 Characterization

In this section we show existence of stationary equilibrium with cutoffs. We characterize distributions, value functions, inaction region and bid-ask spread.

Proposition 1 (Existence)**.** *If $f < s$ and G with bounded support, there exists a stationary equilibrium with cutoffs: with value functions V, W, pdf dH and masses F satisfying 3-12.*

Proposition 1 establishes existence of symmetric stationary equilibrium

Proposition 2 (Characterization)**.** *In equilibrium*

1. *$V(q, \cdot)$ are strictly piecewise linear and differentiable everywhere except at cutoffs*
2. *$dH(q, \cdot)$ are piecewise constant*
3. *$\delta_1^* < \delta_0^*$*

Moreover for G uniform :

$$P_1 - P_0 = \frac{\delta_0^*(P_1) - \delta_1^*(P_0)}{r + \gamma} = \frac{1}{2(r + \gamma)}$$

Linear and monotonous value functions ensures existence of cutoffs.
Final part of proposition 2 establishes inaction region-agents between δ_1^* and δ_0^* no matter the asset position wont be interested in trade once they meet appropriate flipper.
Linearity of value functions and of cdfs allows us to characterize spread and note that inaction region will consist of half of all households (search parameter invariant).
This result relies on assumption that exogenous distribution of types G is uniform.

Let's notice that spread (return) is not a function of market structure-search friction or mass of flipper.
That means that spread is unaffected by competition nor speed at which trade opportunities realize.

Ignore this box. How to write it in more compact way? Just FOCS-explain Maybe define Buyers region, Inaction Region and Seller Region??

Sketch of proof In equilibrium flipper without a house who meets a seller has a total contact rate of $\lambda \int_0^{\delta_1^*(P_0)} dH(1,\delta)$ this is his quantity (fraction) of trades as function of his price offer P_0. Secondly he pays P_0 and he changes state so he has reservation value of $W(1) - W(0)$.

$$rW(0) = \max_{P_0} \lambda \int_0^{\delta_1^*(P_0)} dH(1,\delta)[-P_0 + W(1) - W(0)]$$

Similar observation for flipper-seller of asset allows to write:

$$rW(1) = \max_{P_1} \lambda \int_{\delta_0^*(P_1)}^{\bar{\delta}} dH(0,\delta)[P_1 + W(0) - W(1)]$$

The problem of flipper resembles problem of monopolist who by choosing price affects quantity. Suppose that equilibrium price P_0 has been perturbated and increased by infinitesimal amount- there is a new gain to flipper without a house- higher rate of meeting interested seller but there is a additional cost-namely that he has to pay a bit more. In equilibrium marginal changes of costs and benefits equalize which allows us derive it as first order condition using this perturbation:

$$\underbrace{\int_0^{\delta_1^*(P_0)} dH(1,\delta)}_{\text{MB to } F(1)\text{from charging less}} = \underbrace{[-P_0 + W(1) - W(0)] \cdot \delta_1'^*(P_0) \cdot dH(1,\delta_1^*(P_0))}_{\text{MC to } F(1)\text{from decreasing prices}}$$

Likewise for flipper who is selling a house perturbation of form decreasing a price around equilibrium price P_1 allows us to get:

$$\underbrace{\int_{\delta_0^*(P_1)}^{\bar{\delta}} dH(0,\delta)}_{\text{MB to } F(1)\text{from charging more}} \qquad = \underbrace{[P_1 + W(0) - W(1)] \cdot \delta_0'^*(P_1) \cdot dH(0, \delta_0^*(P_1))}_{\text{MC to } F(1)\text{from increasing prices}}$$

In appendix we are able to derive formulas for $W(1), W(0)$:

$$W(0) = \frac{\lambda(\delta_1^*)^2}{r(r+\gamma)} dH(1, \delta_1^*)$$

$$W(1) = \frac{\lambda(1-\delta_0^*)^2}{r(r+\gamma)} dH(0, \delta_0^*)$$

In appendix we express price spread as function of cuttoffs

$$P_1 - P_0 = \frac{\delta_0^* - \delta_1^*}{r+\gamma} = \frac{1}{2(r+\gamma)} \tag{13}$$

Notice that neither f or λ enter this equation. This result confirms case of DGP in case of monopolistic dealer.

3 Data

In this section, I describe datasets related to the Irish housing market: universe of transaction data, household data and information on housing quality.
I present relevant statistics and patterns from these datasets, which are used to calibrate the model in the subsequent section.
Additionally, I find price distribution of average house where I ran regressions of prices on location $\times$ time fixed effects.
Finally I find correlations of local and nationwide fractions of flipped transactions.

Findings from this section can be summarized by following list with changes calculated for year 2012 and 2021:

Fact 1 The number of flipped transactions was 4.55% of total volume of transactions in 2012 and nearly double to 8.05% in 2021.
Fact 2 Observables explain 40% of variation of house prices.
Fact 3 Real house prices grew by 76%, average house price grew by 68% and expressed in number of years of average consumption by 47%.
Fact 4 Mortgage rates decreased from 3.62% to 2.47%.
Fact 5 Total trade volume of trade increased by 135%.
Fact 6 There is negative correlation between prices and level of intermediation.
Fact 7 Average gross return on flipped houses increased from 1.29 to 1.32. And are higher than on other multiply traded houses in sample.
Fact 8 Dispersion of log prices decreased by 7%.

3.1 Data sets

We utilize three data sets to study effects of flipping: *transaction data*, *cross-section data on households* and *data on quality of houses* for Ireland.
First data set is administrative data[8] from the Residential Property Registry of Ireland, covering all residential property transactions between 2010 and early 2024.
The dataset contains detailed information on 638,751 transactions of over 513,506 unique homes, including: transaction dates (exact day of transaction), prices, exact addresses,

[8] it is tax data from collecting stamp duty- sales tax on houses

and whether the property is a new house or an old dwelling.
Due to definition of 2 year time leg between trades in defining flipping, I will present evidence for data between 2012 and 2021 highlighting that in quantitative changes focus is on year 2012 and 2021 only.
Approximately 20% of these transactions are trades of houses multiple times in sample. Stock of housing in Ireland between 2010 and 2024 is roughly constant at 2 mln houses[9].
That data is used to identify flipping transactions and for volume of trade and prices.
We incorporate data from Household Finance and Consumption Survey (HFCS) cross section data provide detailed information on the financial conditions of households.
It is collected for Eurozone countries and in particular contains information about home-ownership, consumption, mortgages and income [10].
We use second and forth wave[11] of HFCS.
House in this survey defined is as household main residence.
Last data set comes from the Sustainable Energy Authority of Ireland, which provides detailed information on the energy efficiency and physical characteristics of houses such as number of square meters, number of rooms, windows and doors. Issuing energy efficiency certification is mandatory in order to list house for sale.
We have daily date of such inspection which we will claim as putting house on market.
Change this Note facts about changes in quality of housing from sellers distributions .

3.2 Statistics

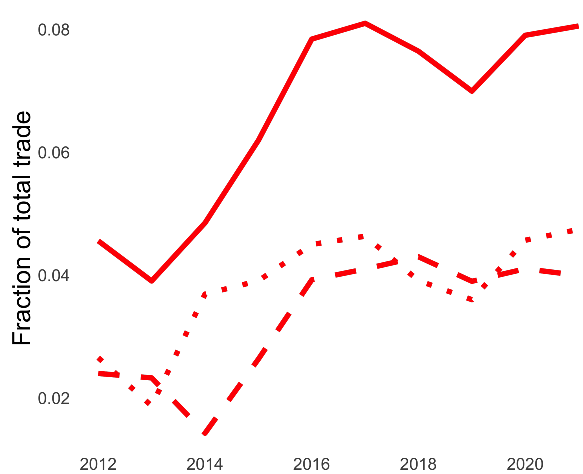
First, use data set of all residential property transactions (houses, apartments, condos and construction sites).
We identify house by its exact address.
Using information about data of transaction allows us to identify houses which have been:(a) never retraded in our sample, (b) flipped (traded between 30 day[12] and 2 years either leg) or (c) traded multiple times but not flipped.
We drop suspicious observations of properties retraded in multiples within 30 days [13]

[9] source: Irish census
[10] Note: this data set is similar to Survey of Consumer Finances (SCF)
[11] For most countries the fieldwork was carried out in 2010 and 2011 for the first wave (2010), between 2013 and the first half of 2015 for the second wave (2014) - with Irish cross section collected in 2013- and in 2017 for the third wave (2017). While the fourth wave (2021) was carried out between the first half of 2020 and the first half of 2022
[12] for calculating house price indexes (HPI) we use 90 days which comes from housing literature
[13] quite often apartments registered as single address and sold within short period of time

and of abnormal gross returns [14].
This eliminates housing units sold in bulk (quite often apartment buildings saved in our dataset without separate apartment unit number) and those houses which underwent extreme change.
In effect that reduces our sample by less than 1%.
Our procedure if anything underestimates a fraction of fast trades.

Margin of flipping Figure 2 is a central figure of this paper.
Red line shows the fraction of house transaction which where either the purchase or sale occurred within less than 2 years - applying literature definition of flipping absent of conditioning on improvement of quality of housing.
It nearly doubled, from 4.55% in 2012 to 8.05% in 2021.
Dotted (dashed) red line shows fraction of transactions where flip was on buyer (seller) side.
Overall buyers and seller flips don't suggest inbalance and holding by either type of flipper[15].

Figure 2: Flipping in Ireland 2012-2021



Notes: Red line shows the fraction of house transaction which where either the purchase or sale occurred within less than 2 years - applying literature definition of flipping absent of conditioning on improvement of quality of housing. It doubled, from 4% in 2012 to 8% in 2021. Dotted (dashed) red line shows fraction of transactions where flip was on buyer (seller) side. Overall buyers and seller flips don't suggest inbalance and holding by either type of flipper.

[14] within $(-\infty, 10000\%]$ annual return excluding less than 500 observations out of 25k flipped addresses- most likely mistakes in data collection.

[15] That matters for quantiative model in which abovementioned trade balance in stationary equilibrium is one of equilibrium conditions

Table 1 contains statistics on mean prices for flippers, non flipped multiply traded and average prices for all houses.
All house prices are in 2012 euros.

Table 1

Year	No retrade	Retraded < 2y	Retraded ≥ 2y	Overall
2012	194,900	148,900	158,200	190,700
2013	205,900	139,400	169,600	200,800
2014	219,200	150,200	183,300	209,400
2015	223,100	167,000	197,400	215,800
2016	249,900	193,700	213,400	240,100
2017	267,800	213,500	241,800	259,700
2018	295,700	220,600	262,200	285,600
2019	306,200	227,900	263,300	295,100
2020	321,800	226,800	272,300	307,700
2021	331,600	240,800	299,400	319,800

Note:

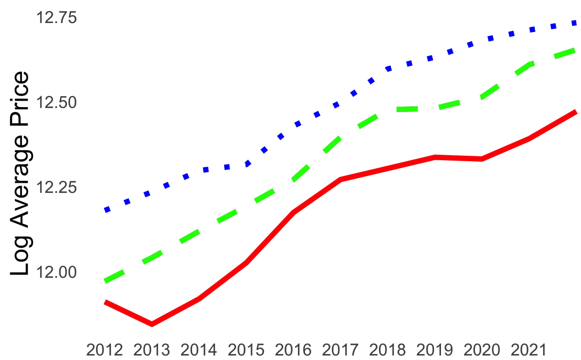
Figure 3 shows behavior of prices across time (right panel) space (left).
Increase between year 2012 and 2021 in average traded price was 76%.
The data reveals that flipped houses are generally cheaper and exhibit lower price variance compared to non-flipped houses.
The latter fact can be found in appendix.
Left panel shows average prices in 2021 across 26 counties of Ireland.
Higher prices are observed in east part of Ireland specifically around county of Dublin, capital city.

Table 2 shows annualized gross returns on multiply traded houses - flipped, traded over more than 2 years, overall.
Those returns are averaged at the year of second trade.
What is notable is that returns on flipped houses are uniformly higher.
Lower values of non-flipped trades early in sample comes from composition of sample - limit of observed transactions in past.
For that reason only returns on flipped houses would be used in later Section 4.

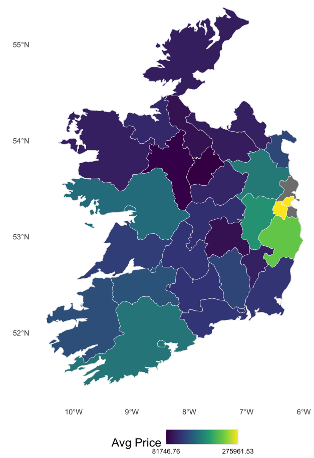
Results from HFCS, a survey household data, are summarized in Table 3.

Figure 3: Prices

(a) Prices change across time



(b) Across space



Note:

Table 2

Year	Retraded < 2y	Retraded ≥ 2y	Overall
2012	1.29	0.93	1.22
2013	1.28	0.97	1.18
2014	1.47	1.00	1.29
2015	1.55	1.11	1.42
2016	1.45	1.16	1.36
2017	1.45	1.14	1.30
2018	1.38	1.15	1.25
2019	1.33	1.12	1.19
2020	1.27	1.10	1.15
2021	1.32	1.10	1.15

Note:

Those moments capture characteristics of Irish housing market in 2012 and 2021.
One can find: homeownership rate, average: house value, other property value, price of house at acquisition; time owner lives in a house, consumption and information related to mortgages.
Irish households tend to use more than one mortgage to finance their housing asset purchase. This motivates using average mortgage rate on all mortgages for later calculates of discount rate in Section 4.

Table 3

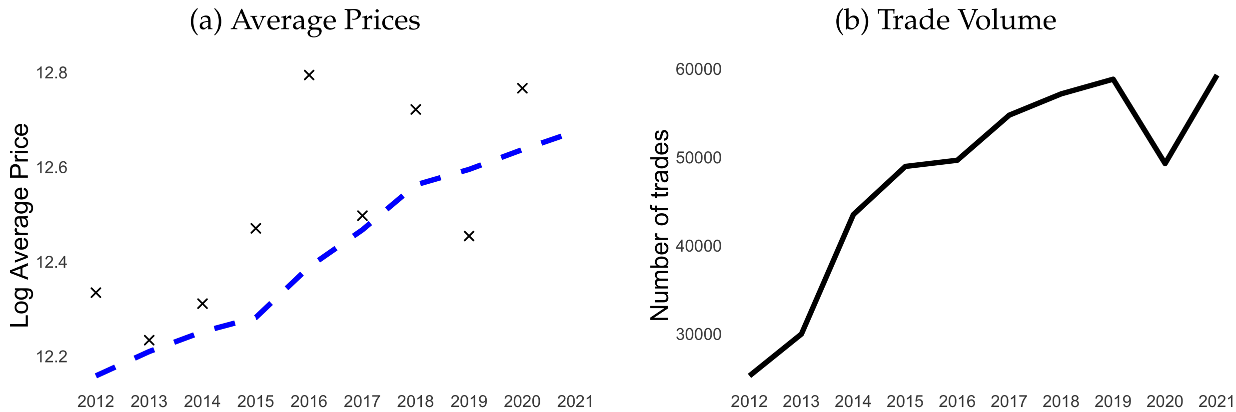
Variable	**Moment**	**2012 Value**	**2021 Value**
Homeownership	Fraction	68.84	69.05
Mortgage Rate	Net Rate	3.62	2.47
Consumption	Mean	17,000	19,000
Live in House	Mean years	17.88	17.28
Home Value	Mean	190,000	316,000
Other Property	Mean	391,000	448,000
Wealth	Mean	216,000	370,000
Size of House	Mean sqm	111	129
Home Price at Acquisition	Mean	157,000	176,000
Current Home Value	Mean	192,000	316,000
Nr of Mortgages on hmr	Mean	1.52	1.56
Nr of Properties	Mean	1.77	1.80
Income	Mean	55,000	71,000

Note:

Figure ?? presents average prices using both transaction on survey data (left panel) and volume of trade from transaction data (right panel).
Using forth panel of HFCS we marked (as x) average prices at time of acquisition.
Average prices from transaction data (blue dotted line) shows true average prices.
For almost all years survey responses overestimates house prices.
This highlights importance of using both full price distribution and tax data instead of survey sources.
Right panel presents volume of traded houses between 2012 and 2021 which increased by 135%.
Freeze in trade due to Covid pandemic seems to be isolated only to 2020 year.
This and fact that HFCS was conducted every 3 years allowed to conduct 2012-2021 analysis instead of restricting sample to pre 2020, making further analysis of stationary economies: one in 2012 and one in 2021.

Average house prices For a sake of model average house in our sample is object of interest.
To find average house price distribution I exploited observable variation in data. First, calculate residual prices by regressing log prices on observables.

Figure 4: Prices and Quantities



Note:

We take residuals of such regression and add estimated average fixed effects and take exponent.
This way of working can address the issue of fat tails and does not require reducing sample for extreme observations.
In baseline case we will use city and quarter-year fixed effects.
Alternative set ups are presented in Table 4 with details of regressions in appendix.

Table 4: Variation Explained by Observables

Fixed Effects	R^2
County	0.27
City	0.36
District	0.50
City, Quarter-Year	0.42
District, Quarter-Year	0.57

In particular $R^2 = 40\%$ for city, quarter-year fixed effects set up shows that there is a non-trivial dispersion in residual prices which we will connect to unexplained heterogeneity due to household types distribution.
Literature on house prices [16] supports this observation finding similar levels of observable variation.

Table 5 presents prices of average house for different years.
Increase between year 2012 and 2021 in average house price was 68%.

[16] add references here

Table 5

Year	No retrade	Retraded < 2y	Retraded ≥ 2y	Overall
2012	161,400	175,300	160,800	162,000
2013	163,900	162,500	159,400	163,600
2014	183,200	164,800	165,200	179,100
2015	192,100	176,200	181,300	189,500
2016	214,700	203,700	199,500	211,600
2017	229,500	217,600	220,500	227,300
2018	249,800	233,700	240,200	247,400
2019	255,300	243,000	246,600	253,300
2020	269,200	247,100	253,100	265,300
2021	287,700	269,900	282,100	285,500

Note:

Flipping and local prices- CHANGE THIS We run location, year fixed effects regression of prices on fraction of flipped transactions (in location transaction in that year).
As a result we noted that higher fraction of flipped transactions by 1% is associated with lower local average prices by 2%.
Results of regression can be found in first column of table xyz.

$$\log \hat{P}_i = \alpha_t + \gamma_l + \beta \mu_{l,t}$$

4 Quantitative Model

In this section we extend ways households trade in housing asset market.
From now on we allow them to buy and sell housing asset from other households.
We follow here Hugonnier et al. (2020) in adding two sided heterogenous trade with surplus split via Nash bargaining.

Discussion of computational algorithm is in appendix [17].
In later part, I estimate model to empirical methods using minimum distance estimation to match empirical moments of Irish economy in 2012.
I discuss main mechanism of the model- the way search friction propagate into distributions and value functions.
Next I simulate the model and focus on behavior of types around time of trade.
I use counterfactual exercise to think about effects of increase in fraction of flippers in economy on whole price distribution, trade and welfare.
Main exercises matches share of flipped trade with magnitude observed between 2012 and 2021 in Ireland.
Second exercise compares changes in f with what literature calls in case of studying effects of intermediation, i.e. changes in λ.
Key insight here is that welfare effects for flippers in latter exercise are unrealistically big.
Finally, I conduct policy experiment in which sales tax of 9% is imposed on flippers similar to which Ireland had until 2011[18].

4.1 Allowing Household - Household trade

Building on Section 2 we add another way for trade between agents to occur.
Additional to household vs flipper trade- which happens at one-on-one rate λ we allow for another type of meetings.
Now households can trade also with each other in housing assets and one-on-one meeting rate is ρ.
Meetings are random and masses of traders meet.
Conditional on meeting if trade surplus is positive, it is split via Nash bargaining 50-50 between buyer and seller.
The way we introduce inter-houshold trade follows closely Hugonnier et al. (2020).

[17] Which to our knowledge is first which combines continuous time methods for finding value functions with recursive update of cuttoffs

[18] To our knowledge this is first analysis of this type of tax policy in context of search model

Shocks to current type δ happens with rate γ.
Supply of housing asset is s and discount rate is r.
Central object is *reservation value* defined as:

$$\Delta V(\delta) = V(1,\delta) - V(0,\delta)$$

which relates value of having an asset to lack thereof.

Shoul I explain: focus on flipping who are inpatient and for hh vs hh trade there is complicated game in a background which i dont model explicitly and i split surplus 50:50

Household's problem **Seller:** Homeowner household with valuation δ gets: flow utility δ, can change it's type which happens with γ rate and it's drawn from distribution G and trade opportunity with flipper without a house arrive at rate λ while trade opportunities with other households arrive at rate ρ.
Conditional on specific meeting and positive surplus, household sells a house to a flipper without a house (for P_0) or to other household (with type δ' for $P(\delta,\delta')$) and becomes non owner.
Using Bellman optimality principle value function is characterized by:

$$rV(1,\delta) = \underbrace{\delta}_{\textbf{flow}} + \underbrace{\gamma\int_0^{\bar{\delta}}[V(1,\delta') - V(1,\delta)]dG(\delta')}_{\textbf{change of type}} + \underbrace{\lambda F(0)\cdot\max\{P_0 - \Delta V(\delta), 0\}}_{\textbf{HH vs F trade surplus}} +$$

$$+\underbrace{\rho\int_0^{\bar{\delta}}\max\{P(\delta,\delta') + V(0,\delta) - V(1,\delta), 0\}dH(0,\delta')}_{\textbf{HH vs HH trade surplus}}$$

Buyer: On the other hand, household without a house with type δ has: 0 flow utility, can experience shock to it's current type δ with rate γ.
With intensity λ meets with flipper with a house and with rate ρ meets with other household with a house with type δ'.
If a household buys from flipper (pays for it P_1) or from other household (with type δ' for

$P(\delta, \delta')$ and becomes owner.

$$rV(0,\delta) = \underbrace{\gamma \int_0^{\bar{\delta}} [V(0,\delta') - V(0,\delta)] dG(\delta')}_{\textbf{change of type}} + \underbrace{\lambda F(1) \max\{-P_1 + \Delta V(\delta), 0\}}_{\textbf{HH vs F trade surplus}}$$

$$+ \underbrace{\rho \int_0^{\bar{\delta}} \max\{-P(\delta,\delta') + V(1,\delta) - V(0,\delta), 0\} dH(1,\delta')}_{\textbf{HH vs HH trade surplus}}$$

Prices Prices proposed by flippers are such that marginal household with oposite asset position has all the surplus extracted.
Therefore, price offered by flipper-seller (buyer) P_1 (P_0) extracts from household-buyer (seller) δ_0 (δ_1), so:

$$P_1 = \Delta V(\delta_0) \qquad P_0 = \Delta V(\delta_1)$$

When trade between buyer δ and seller δ' households happens they split the surpluses in half:

$$P(\delta, \delta') = \frac{1}{2}\Delta V(\delta) + \frac{1}{2}\Delta V(\delta')$$

Necessary condition for trades to follow in equilibrium are that buyer's type is higher than seller's,i.e. $\delta' \geq \delta$. We break ties by allowing flippers to trade if they have identical deltas.
Note that trade between *low* delta owner and *high* delta non owner can happen. Also trade between *high* owner and *low* delta owner can follow.

Reservation value representation Notice that in equilibrium only sellers with lower type will trade with buyers with higher type.
This combined with expression for prices between households yields for owners:

$$rV(1,\delta) = \delta + \gamma \int_0^{\bar{\delta}} [V(1,\delta') - V(1,\delta)] dG(\delta') + \lambda F(0)(\Delta V(\delta_1) - \Delta V(\delta)) \mathbb{1}[\delta < \delta_1] +$$

$$+ \rho \int_{\delta}^{\bar{\delta}} \frac{1}{2}[\Delta V(\delta') - \Delta V(\delta)] dH(0, \delta')$$

with last integral summing over non owner types higher than δ.

For non owners problem becomes:

$$rV(0,\delta) = \gamma \int_0^{\bar{\delta}} [V(0,\delta') - V(0,\delta)]dG(\delta') + \lambda F(1)(-\Delta V(\delta_0) + \Delta V(\delta))\mathbb{1}[\delta > \delta_0] +$$

$$+\rho \int_0^{\delta} \frac{1}{2}[\Delta V(\delta) - \Delta V(\delta')]dH(1,\delta')$$

with last expression integration over lower deltas of owners.

Subtracting gives us representation for reservation values which comes from three sources of value of assets: from flow utility, shock to type and delayed and random trade opportunities:

$$\begin{aligned} r\Delta V(\delta) = \delta + \gamma \int_0^{\bar{\delta}} [\Delta V(\delta') - \Delta V(\delta)]dG(\delta') \\ + \lambda F(0)(\Delta V(\delta_1) - \Delta V(\delta))\mathbb{1}[\delta < \delta_1] + \lambda F(1)(\Delta V(\delta_0) - \Delta V(\delta))\mathbb{1}[\delta > \delta_0] \\ + \rho \int_{\delta}^{\bar{\delta}} \frac{1}{2}[\Delta V(\delta') - \Delta V(\delta)]dH(0,\delta') + \rho \int_0^{\delta} \frac{1}{2}[\Delta V(\delta') - \Delta V(\delta)]dH(1,\delta') \end{aligned}$$

This problem can be represented using an object characterizing agent specific discount rate which takes into account additional to opportunity cost r, a shock to types and random trade opportunities, call it *endogenous discount rate*. Formally:

Definition 2. *Endogenous discount rate:*

$$\sigma(\delta) = r + \gamma + \lambda F(0)\mathbb{1}[\delta < \delta_1] + \lambda F(1)\mathbb{1}[\delta > \delta_0] + \frac{\rho}{2}\int_{\delta}^{1} dH(0,\delta') + \frac{\rho}{2}\int_0^{\delta} dH(1,\delta')$$

At this point we can see also endogenous rates of meeting a flipper $\lambda F(0)$, $\lambda F(1)$ and with other households $\frac{\rho}{2}\int_{\delta}^{1} dH(0,\delta')$, $\frac{\rho}{2}\int_0^{\delta} dH(1,\delta')$.

Using effective discount rate allows us to rewrite value function as:

$$\sigma(\delta)\Delta V(\delta) = \delta + \gamma \int_0^1 \Delta V(\delta')dG(\delta') + \lambda F(0)\Delta V(\delta_1)\mathbb{1}[\delta < \delta_1] + \lambda F(1)\Delta V(\delta_0)\mathbb{1}[\delta > \delta_0] +$$

$$+\frac{\rho}{2}\int_{\delta}^{1} \Delta V(\delta')dH(0,\delta') + \frac{\rho}{2}\int_0^{\delta} \Delta V(\delta')dH(1,\delta')$$

This representation separates: type specific δ discount -$\sigma(\delta)$ and δ reservation value-

$\Delta V(\delta)$, from total flow on the right hand side. Total flow comes from agent specific flow utility, from expected payment in case of trade with flippers and households.

Flippers problem Flippers behavior remains like in Section 2 so we skip it here.
To determine equilibrium we note here expressions for value function of flippers with a house:

$$W(1) = \frac{\lambda}{r} \frac{[\int_{\delta_0(P_1)}^{1} dH(0,\delta')]^2}{\sigma(\delta_0) dH(0,\delta_0)}$$

where

$$\sigma(\delta_0)^{-1} = r + \gamma + \frac{\rho}{2} \int_{\delta_0(P_1)}^{1} dH(0,\delta') + \frac{\rho}{2} \int_{0}^{\delta_0(P_1)} dH(1,\delta')$$

The difference here with Section 2 is only in the discount rate, instead of r with have a part coming from inter-household trade against relevant parts of distribution.
At cutoff trade with flipper is not happening and thus there is no effect on discount rate there.

In similar way value of flipper without a house is expressed as:

$$W(0) = \frac{\lambda}{r} \frac{[\int_{0}^{\delta_1(P_0)} dH(1,\delta')]^2}{\sigma(\delta_1) dH(1,\delta_1)}$$

where

$$\sigma(\delta_1)^{-1} = r + \gamma + \frac{\rho}{2} \int_{\delta_1(P_0)}^{1} dH(0,\delta') + \frac{\rho}{2} \int_{0}^{\delta_0(P_1)} dH(1,\delta')$$

Problems of flipper and agent can be liked together and one can express reservation values of agents at cutoffs as:

$$\Delta V(\delta_0) = (1 + \frac{r}{\lambda}) W(1) - W(0)$$

$$\Delta V(\delta_1) = W(1) - (1 + \frac{r}{\lambda}) W(0)$$

In other words, value of marginal household is reservation value of flipper with correction caused by delayed in trade.

Envelope condition. In equilibrium endogenous discount rate equal to inverse of marginal reservation value:

$$\sigma(\delta) = \frac{1}{\Delta V'(\delta)}$$

Stationary distribution Following closely notation from Section 2 we focus on flow equation using cumulative distributions.

Homeownership (inflow and outflow to $[0,\delta], q = 1$)

$$\underbrace{\lambda F(1) \int_{\delta_0^*}^{\max\{\delta,\delta_0^*\}} dH(0,\delta') +}_{\text{F } \textbf{sells} \text{ to HH}} \quad \underbrace{\gamma G(\delta) \int_{\delta}^{1} dH(1,\delta')}_{\text{inflow from change of type from}[\delta,1]} \quad = \tag{14}$$

$$= \underbrace{\lambda F(0) \int_{0}^{\min\{\delta,\delta_1^*\}} dH(1,\delta') +}_{\text{F } \textbf{buys} \text{ from HH}} \underbrace{\gamma(1-G(\delta)) \int_{0}^{\delta} dH(1,\delta')}_{\text{outflow from change of type to}[\delta,1]} + \underbrace{\rho \int_{0}^{\delta} dH(1,\delta') \int_{\delta}^{1} dH(0,\delta')}_{\text{HH trades with HH}} \tag{15}$$

To characterize trade volumes (overall, and each type), as rate per period, we use following definition in spirit of OTC literature:

Definition 3 (Trade Volumes)**.** *Denote by κ, κ_1 and κ_2 overall, household vs household and flipper vs household trade volumes respectively. Then:*

$$\kappa = \underbrace{\rho \int_0^1 \int_0^1 \mathbb{1}[\delta' \geq \delta] dH(1,\delta) dH(0,\delta')}_{\kappa_1 - \textbf{\textit{HH vs HH}} \textit{ trade}} + \underbrace{\lambda F(0) \int_0^{\delta_1(P_0)} dH(1,\delta') + \lambda F(1) \int_{\delta_0(P_1)}^{1} dH(0,\delta')}_{\kappa_2 - \textbf{\textit{F and HH}} \textit{ trade}}$$

Distinction between trade between household κ_1 and κ_2 would be central in calibrating the model.
Note that above we count successful trades and those happen between household only if seller has lower δ than buyer's δ'.
Also last two integrals would be equal as volume of houses sold and bought in total by flippers is equal.

Definition 4 (Price distribution)**.** *F is cdf of prices:*

$$F(p) := \frac{\rho}{\kappa} \int_0^1 \int_0^{\delta'} \mathbb{1}[P(\delta,\delta') \leq p] dH(1,\delta) dH(0,\delta') + \frac{\kappa_2}{2\kappa} \mathbb{1}[P(0) \leq p] +$$

$$+\frac{\kappa_2}{2\kappa}\mathbb{1}[P(1) \leq p]$$

The last two elements - prices from flipper's trade

Now I characterize economy where there is no search frictions.
That would be reference for trade happening immediately via centralized market with unique price.

4.2 Frictionless limit

Consider an economy with mass f of flippers in which trade happens immediately, in Walrasian fashion. There is no search friction and interested parties at every time can exchange housing asset in annonymous exchange.
In that case, in the equilibrium top s agents who value the asset the most will hold it[19].
Given that in such economy flippers don't value housing asset at all, households with δ equal and above $1-s$ have all asset in equilibrium.
Let's denote lowest house owner δ^* . The price P^* for which market clears is equal to present value of δ^* agent holding asset forever.
Thus: $P^* = \frac{\delta^*}{r} = \frac{1-s}{r}$.
At any point in time due to shock γ mass of agents ends up in wrong asset position and trades immediately. Rate at which owners will end up in wrong asset position is γ per owner (mass of $G(\delta^*)$ and they would trade with non owners who would like to trade which mass is $1-G(\delta^*)$
Volume of trade as a rate is then $\kappa_F = \gamma(1-G(\delta^*))G(\delta^*) = \gamma s(1-s)$ while turnover is equal to $\gamma(1-s)$. We can express also demand elasticity as $-\frac{d(1-G(Pr))}{dP}\frac{P^*}{1-G(P^*r)} = \frac{1-s}{sr}$[20].

4.3 Computation

Computation of equilibrium requires solving for two cutoffs, two value functions, endogenous distributions for households and masses for flippers.
Hard part of problem is to find cutoffs.
It relies on generalization of the proof of existence from Section 2 which part is showing fix point on recursion for cutoffs.
General idea follows from combining recursion on cutoffs and solving value function it-

[19] Consider trade in equilibrium from section 2 - there flippers have to hold some of housing stock if non zero trade happens in equilibrium. Or there would be autarky.
[20] think is it even correct, can i recover it in case of my model theoretically and maybe i should report those numbers and discuss

eration for reservation values using continuous time methods. For fixed cutoffs I use equations related to stationary distributions (law of motion, balance of trade for flippers and accountings) to find relevant masses and distributions.
Value functions of flippers are explicit function of distribution, masses and cutoffs.
Next, I use them to solve reservation value function problem of households by discretizing grid on δ types and using integration as linear operator to represent it in matrix form. Solving this essentially means invert numerically well conditioned matrix.
Reservation values of households at cutoffs allows to introduce iteration on cutoffs [21] which makes algorithm converge[22].
Once convergence is achieved we solve for individual value functions of household given reservation values solving two standard discrete value function iterations.
Details for numerical solution and algorithm are described in appendix.

4.4 Matching data with model

The way we define flipping in a data is by separating flippers with households using time between double trades: flippers are identified as those who conduct both transactions under 2 year limit and household when retrade takes over 2 years. The model uses exponential random variables which implies that multiple trades are exponential. In particular that there are non-trivial masses of trade of : households with households within 2 years and flippers with household in over 2 years between trades. The former rate is equal:

$$\rho \int_0^1 \int_\delta^1 dH(0,\delta') * \exp(-2\rho \int_0^\delta dH(1,\delta''))dH(1,\delta)$$

And the latter is equal:

$$\lambda F(0) \int_0^{\delta_1} dH(1,\delta')(1-\exp(-2\lambda \int_{\delta_0}^1 dH(0,\delta''))) + \lambda F(1) \int_{\delta_0}^1 dH(0,\delta')(1-\exp(-2\lambda \int_0^{\delta_1} dH(1,\delta'')))$$

This allows us also in clear way to match returns of flippers in model $\frac{P_1}{P_0}$ to the one's in the data. Data counterpart is calculated as mean return of flipped houses is average across those trades which first leg between 2010 and 2012 and second leg of transaction in 2012.

[21] note that flow utility enters in linear way allowing recursion to have additive form
[22] proof of convergence was done in case of toy model

4.5 Parametrization

External calibration Unit of time is one year. Interest rate is set to 3.62% average mortgage rate in 2012 (calculated using HFCS survey data)[23].
It is standard for housing literature to take this discount rate as opposite to T-bills rates[24].
Rest of parameters was jointly estimated[25].
Targeted moments

We assume here that flippers are non-household agents. With households consumption and homeownership calculated from HFCS survey data.

4.6 Estimation strategy

To estimate the parameters f, λ, ρ, and γ of the model, we use a minimum distance estimator (MDE).
The goal is to match the following moments: the share of flipped transactions, the average price of houses, the return on flipping, and the average time since moving into a house.

The minimum distance estimator seeks to find the parameter values that minimize the distance between the model-generated moments and the corresponding empirical moments.
Formally, the estimator is defined as:

$$\hat{\theta} = \arg\min_{\theta} \left[(\frac{m(\theta) - \bar{m}}{\bar{m}})' W (\frac{m(\theta) - \bar{m}}{\bar{m}}) \right]$$

where $\theta = (f, \lambda, \rho, \gamma)$ represents the parameters to be estimated, $m(\theta)$ denotes the vector of moments predicted by the model, $\bar{m}$ is the vector of empirical moments, and W is the weighting matrix, in this case identity matrix.

The results of this calibration are summarized in Table 6, which shows the estimated parameters and their fit with the empirical data.

[23] 37% of households own a mortgage and those who own a property quite often have more than one (via Table 3.

[24] add references

[25] parameter f guides share of flipped houses, λ return on flipping ρ

Table 6: Estimation

Parameter	Description	Value			
		Externally	**Source**		
r	Mortgage rate	3.62%	HFCS		
s	Homeownership rate	68.84%	HFCS		
		Matched moments	**Target**	**Model**	**Data**
f	mass of Flippers	2.1%	Fraction of flipped	4.81%	4.56%
ρ	Search HH vs HH	0.3	Average price	11.62	11.42
λ	Search F vs HH	3	Return on flipping	1.27	1.29
γ	Taste shock	7%	Tenure time	2.54%	5.59%

Note: All parameters are estimated to 2012 data. Mortgage rate r and homeownership rate s are externally calibrated to HFCS houshold data. Other four parameters f, λ, ρ, γ are estimated using minimum distance estimator.

Ex-post we verify if conditions of Proposition 1 are satisfied.

4.7 Properties of the model

Figure 5

(a) $\Delta V(\delta)$ (b) $dH(q, \delta)$

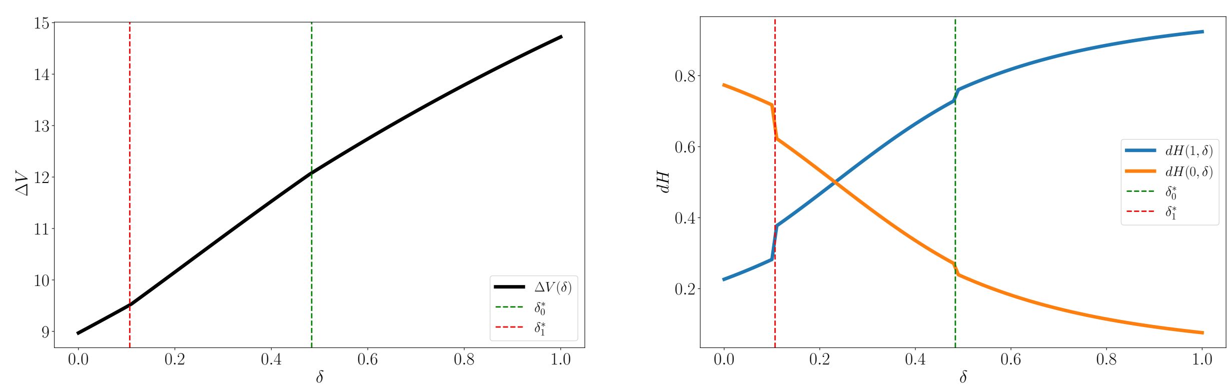
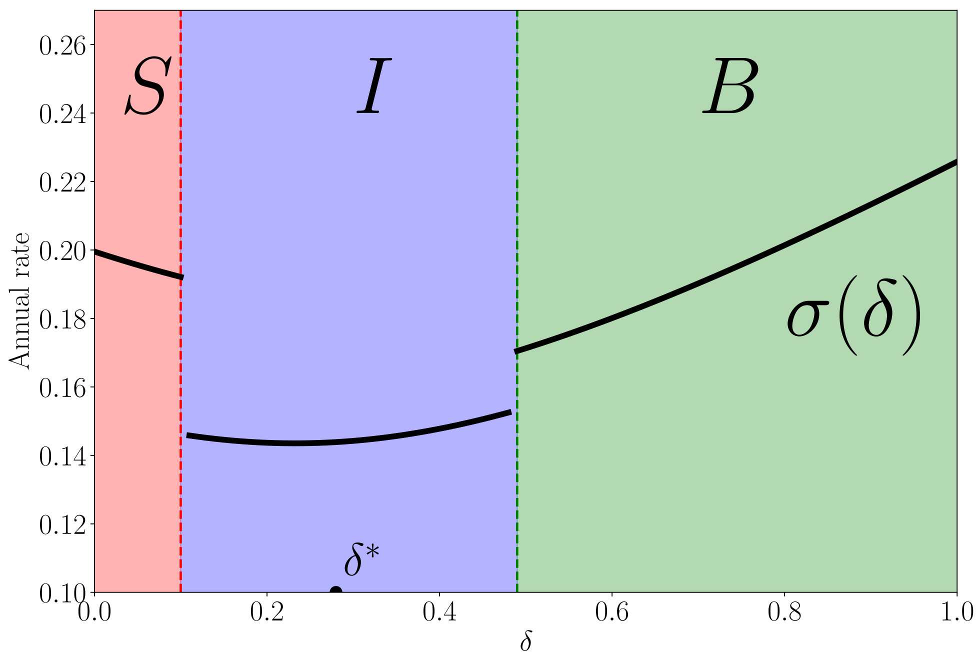


Figure 5 presents reservation values (left panel) and probability distribution functions (right) for owners (blue curve) and non-owners (orange).
Green dotted line marks cutoff δ_1^* below which household homeowner trades with flipper without a house, conditional on meeting.
Above this cutoff owner household won't meet and trade with non-owner flipper.
In similar way, household at cutoff δ_0^* denotes indifference delta for non-owner house-

hold meeting with flipper who has a house.
Notice that section between $[\delta_1^*, \delta_0^*]$ marks inaction region where trade is only possible between households.
Note that size of this inaction region shrink comparing to Section 2[26].
Reservation values is strictly increasing continuous function with kinks at both cutoffs.

Right panel of Figure 5 shows probability distribution functions of owners (blue) and non-owners (orange). No

Figure 6



Notes: Effective discount rate is an endogenous object.

Figure 6 shows three things: first, there is non monotone relationship in discount factor; second, that value function is first convex and later concave and finally, δ^* type is the one taking part in highest volume of trade (among household)[27].
Also non differentiability occurs only at cutoffs values.

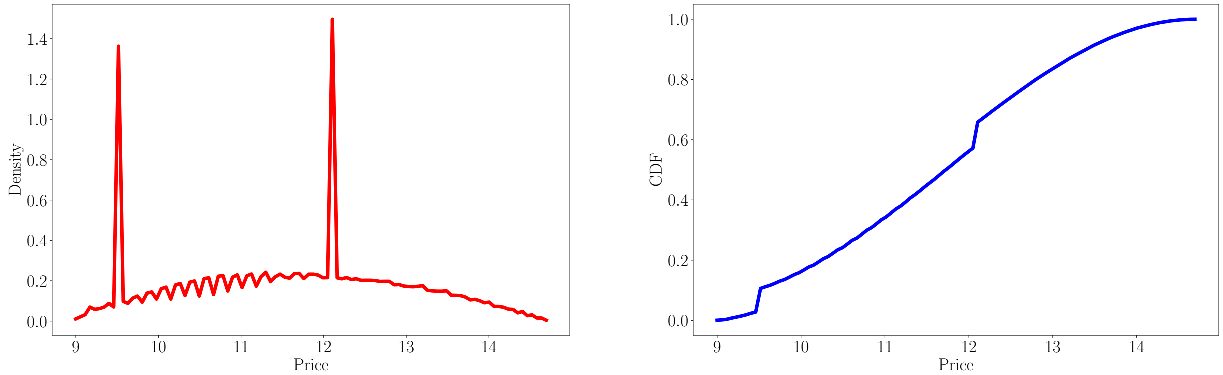
Price distribution presented at Figure 4.7 is characterized by symmetric shape, relatively small variance and kinks.

[26]Where was equal to half of mass of household, the biggest for uniform G.
[27]it is not to say that reservation value of this type is the highest, he will just buy and sell (together) the most among households

Figure 7

(a) Prices pdf

(b) Prices cdf



sss

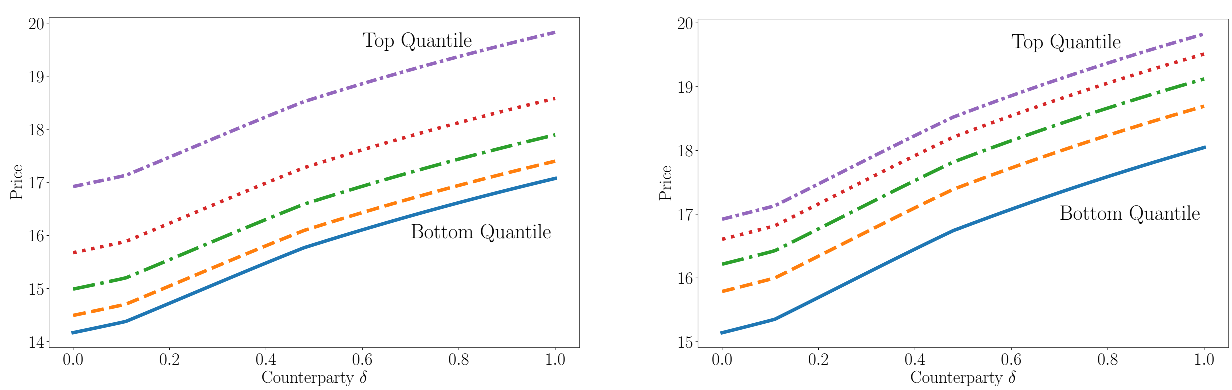
Kinks come from propagation of cutoffs through prices, with the biggest two coming from flipper trade prices.

Explain figure below

Figure 8: Price schedule with Household vs Household trade

(a) Buyers

(b) Sellers



Misallocation and role of flippers Model allows to characterize distributional misallocation by defining for on each interval $[0, \delta]$ mass of households allocated different quantity of housing asset than in frictionless economy:

$$M(\delta) = \int_0^{\delta} \mathbb{1}\{\delta' < \delta^*\} dH(1, \delta') + \int_0^{\delta} \mathbb{1}\{\delta' > \delta^*\} dH(0, \delta')$$

This measure captures how mass of households who own a house in economy with friction who don't own it in frictionless economy (first term) and how many households don't own a house in economy with search friction who otherwise would (second term).

Households enjoy flow utility δ from owning an asset and that evolves stochastically, 0 flow for flippers

then

Figure 9a shows misallocation density defined as:

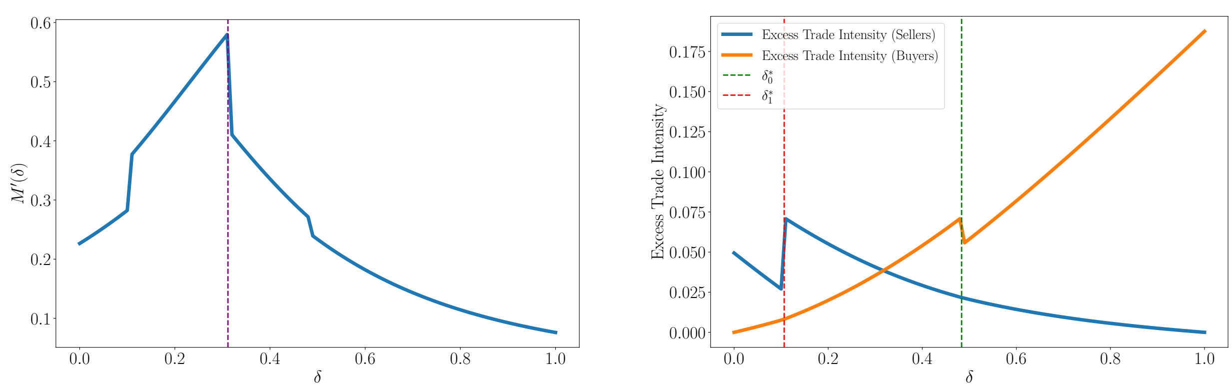
$$M'(\delta) = \mathbb{1}\{\delta < \delta^*\} dH(1, \delta) + \mathbb{1}\{\delta > \delta^*\} dH(0, \delta)$$

we note that misallocation is concentrated right below δ^* and we mostly contribute it to homeowners.
But across whole distribution of private types it is non negligible.

Figure 9

(a) Misallocation density

(b) Excess Trade intensities gross of meeting flipper



Welfare cost of search friction

5 Experiments

Following exercises exploit properties of model obtained by simulating the model [28]. First, I observe that owners and non owners have constant type level in time series. Secondly, agent type drops to local min (max) around transaction time and reverts to mean afterwards.
Thirdly, that there is negative relationship across time between prices and fraction of flipped transactions in certain period.
The last experiment mirrors regression from Section 3 and as untargeted moment hints about fit of the model.

5.1 Model Fit

Simulating model and using data for 2012 I run regression of prices on dummy flipper variable for transactions in which trade happened with flipper:

$$P_i = \alpha_t + \gamma_l + \beta F_i$$

Results suggests

Table 7: Untargeted moment: regression coefficient

	Data	Model
β	-0.21	-0.29
Fixed effects	✓	
Consumption adjusted	✓	

Note: β was calculated in simulation for $T = 100$, discretized wiht $dt = 0.1$ and $N = 10000$ agents. In empirical counter part for 2012 there were 25,238 observations while for 2021 59,296.

Table 9 presents results of exogenous change in r obtained from data on 2021 and performance model in that year.

Plot 10 shows performance of model against data for price distributions. Model calibrated to mean not quite well explains other moments of price distribution, a feature of search models discussed among others in Rekkas et al. (2020).

[28]for $T = 100$ period burning in first 20 periods of sample, across $N = 10000$ draws of agents

Table 8: Untargeted moment: Trade volume as fraction of housing stock

	Data	**Model**
	2012	
Total trade	1.274	1.298
Flipper trade	0.058	0.062
	2021	
Total trade	2.410	1.243
Flipper trade	0.183	0.103

Note: In second part of table f comes from counterfactual (with r at 2012 level) and r was adjusted to 2021 level, no reestimation of model otherwise

Table 9

s, γ, λ, ρ **at 2012**						
	r, f **2012**		f **2012,** r **2021**		r, f **2021**	
	Data 2012	**Model**	**Data 2021**	**Model**	**Data 2021**	**Model**
Fraction of Flipped	4.56%	4.81%	8.05%	4.97%	8.05%	8.28%
Average Price	11.42	11.62	16.78	16.83	16.78	16.66
Return on Flipping	1.29	1.27	1.32	1.19	1.32	1.20
Turnover	5.59%	2.54%	5.79%	2.54%	5.79%	2.69%

Note: When I change r I use data from 2012 and 2021, when i change f I use calibrate to match flipped share

5.2 Behavior of types

The average type level of owner and non owner is constant across time as showned at Figure 11[29].

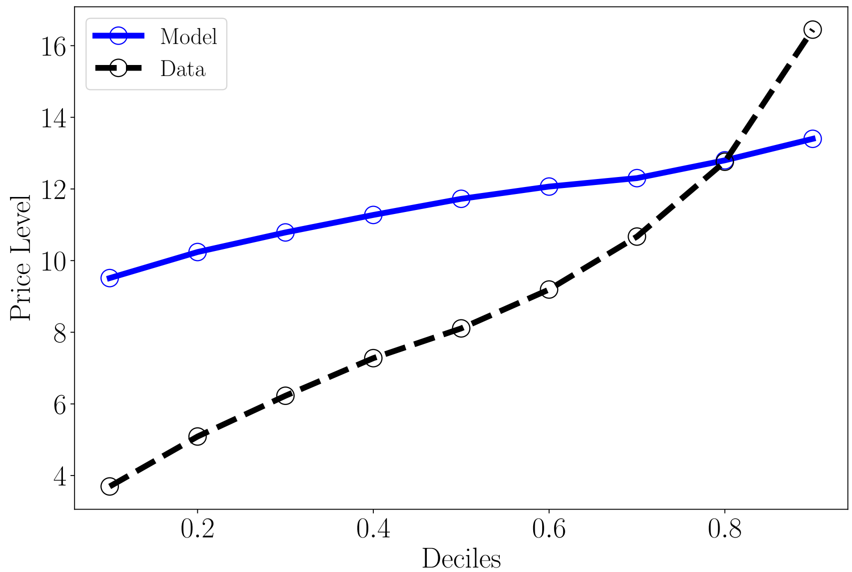
In stationary equilibrium most owners have high delta while non-owners are at lower level.

Indeed, cross section averages cluster around two levels of deltas- lower for non-owners (red) and higher for owners (blue).

The model does not admit the property of houses being owned by higher deltas over time

[29]maybe i should focus on ladders of average delta across houses. i don't track houses or but people in simulation. so maybe drop it shouldnt u?

Figure 10



Notes: XXX.

[30].

It is true that as long as houses passes between households, chain of bilateral transactions puts house in hands of higher and higher delta household.

But once the house is transacted with flipper the chain of deltas breaks and starts at extreme values of delta where trade with flipper is only active- effectively resetting whole ladder.

5.3 Types around date of transaction

Another property of the model is that δ fall (increases) upon trade time for sellers (buyers) and mean revert.

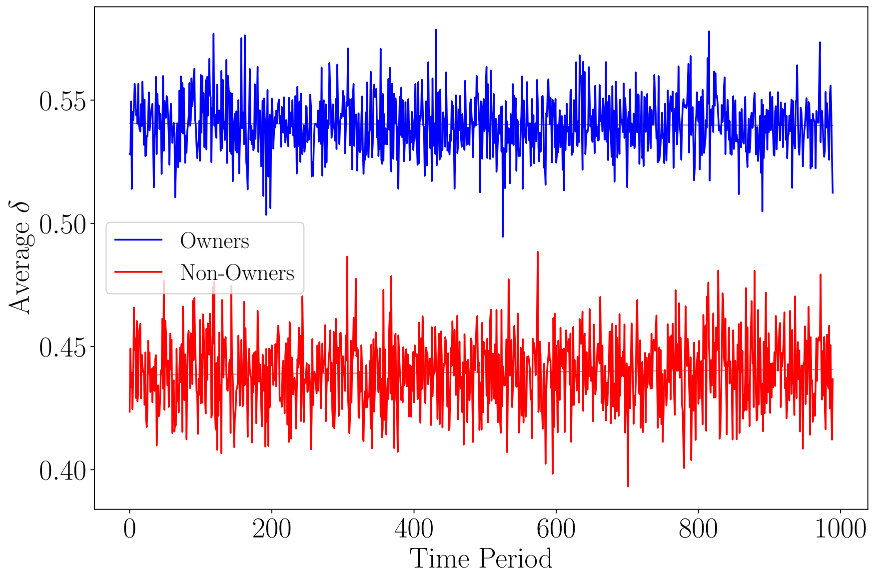
On Figure 12 I conduct and event study of the average change in δ around transaction in house for various types of households- buyers and sellers (left right panel respectively)- with different types of counter party- households or flippers (blue red line respectively).

Using simulation of the model I identify households which traded at time t and center that event.

Following households who engaged in trade at time t backwards and forward, I calculate

[30] Property of job ladder exploited search models in labor literature

Figure 11: Average δ of Owners and Nonowners over time



Notes: XXX.

average type level δ.

It is important to distinguish three type of event that can happen at any point in time but can't happened at once: change of δ, meeting household or meeting flipper. On right panel, sellers valuation is the lowest at time of trade t, decreasing the most for household who end up trading with flipper at that time.

Low delta shock makes chances of selling to household increase.

Very low delta make trade to flipper be possible.

Since trade happens at t, no change in δ happened at that time.

Agent who just sold at time t would have changed his type in $t-1$ or before.

In similar fashion after selling at t agent becomes potential buyer $t+1$ with some fraction of agents experiences shocks to their delta, some meet seller household or flippers.

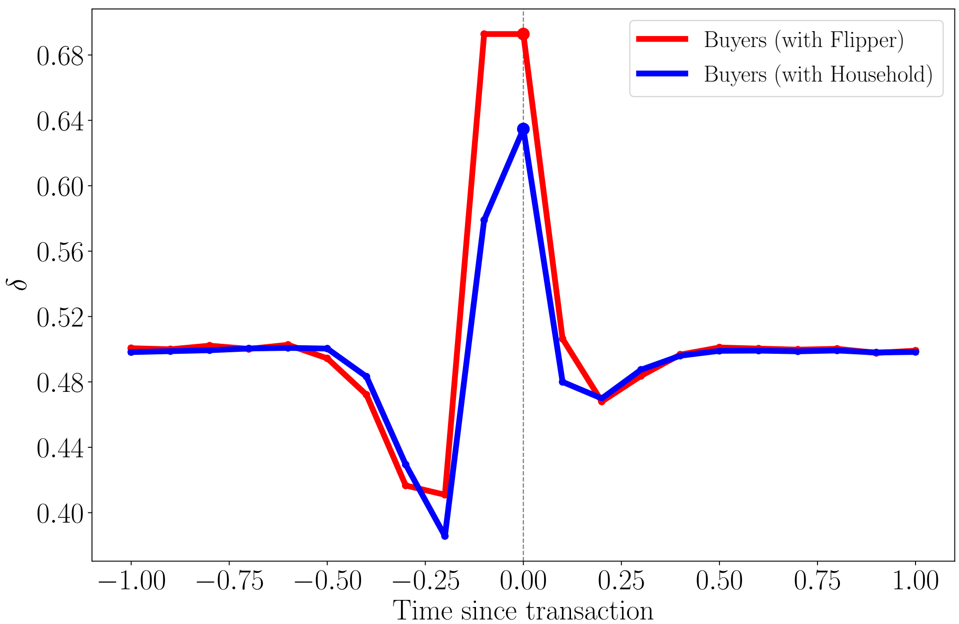
Overall making time $t+1$ group at higher level of δ on average than at time of transaction.

Also nonhomeowner at $t+1$ with low δ level carried from t has relatively high chances of meeting trading partner- this time seller.

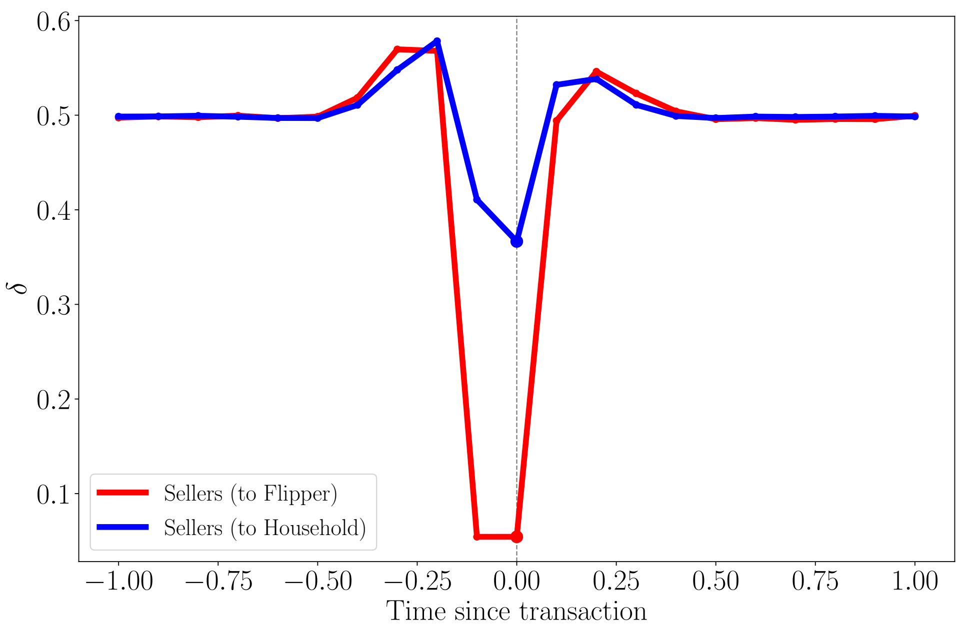
This exercise suggests that trade is triggered by temporary

Figure 12

(a)


Buyers (with Flipper)
Buyers (with Household)
0.68
0.64
0.60
0.56
0.52
0.48
0.44
0.40
δ
−1.00
−0.75
−0.50
−0.25
0.00
0.25
0.50
0.75
1.00
Time since transaction

(b)


0.6
0.5
0.4
0.3
0.2
0.1
δ
Sellers (to Flipper)
Sellers (to Household)
−1.00
−0.75
−0.50
−0.25
0.00
0.25
0.50
0.75
1.00
Time since transaction

5.4 Main Counterfactual Exercises

In this section, we analyze the impact of increasing the fraction of flippers, f, to align with the observed changes in the fraction of flipped transactions in 2012 and 2021.

Our counterfactual analysis compares the baseline year of 2012 with the year 2021, assuming there is only change in f to match shares of flipped transactions.

The changes of moments of price distribution, quantities, return and time are in Table 10.

As the fraction of flippers rises, we observe that mean price and variance has decreased.

Given almost doubling fraction of intermediaries price spillovers are at 0.59%.

What matters here is to relate this change not to change in mass of flippers but to the change in quantities traded [31] While household vs household trade was crowded out by more intermediation, overall trade increased.

Turnover and returns increased.

Table 10: Results of counterfactual increase of f

Variable	% **Change**
Mean Price	-1.51
Var Price	-0.31
Flipper Share	67.42
HH Trade	-7.95
Total Trade	5.16
Return	0.99
Turnover	5.16

Note:

Table 11 decomposes changes in welfare from more intermediation, measured in consumption certainty equivalent between different groups of agents.

Flippers experienced big drop in welfare, caused by more competition between them.

Non-homeowners current welfare increased by substantial 1.01% while homeowners current welfare increased by mild 0.06%.

More intermediation will improve trade options of non-owners more by easing search frictions.

Even though those groups' welfare improves due to more , overall welfare decreases by mild -0.08%. This comes from fact that masses of homeowners and non-owners composition change between scenarios.

The change in owners distribution combined with high level of value function for owners

[31] go to R to find this elasiticty sth around 3

will generate most of this overall negative effect, since with more flippers there is less household owners.

Table 11 decomposes misallocation measured in mass of agents in wrong asset position vis a vis frictionless economy.
Changes in misallocation are in line with changes in welfare. Though welfare takes into account all distribution of agents of each asset position integrated over δ's and misallocation looks at part of this endogenous mass.
More intermediation relaxes misallocation for non-owners by 2.25% and for owners by 1.11%.

Table 11

Variable	% **Change**
Welfare pc	
Total	-2.44
Households	-0.20
Homeowners	0.34
Non-Homeowners	3.02
Flipper	-23.43
Misallocation	
Total	-5.22
Owners	-3.03
Non-Owners	-7.36

Note:

5.5 Effects of Equivalent Increase in λ

In this section, we explore the impact of varying the meeting rate λ as an alternative to changing the fraction of flippers f.
This comparative statics exercise is grounded in the OTC literature, where the meeting rate λ is adjusted to study its effects on intermediation.
We keep meeting rates of flippers $\lambda F(0)$ and $\lambda F(1)$ with previous exercise so such intermediation has fixed contact rates between flipper and household.

Table 12 present the outcomes of this experiment and compares it with previous exercise.

We observe that increasing the meeting rate λ has the opposite effect on prices compared to increasing the fraction of flippers f.

What is evident is that increase in λ causes unrealistic benefit in welfare of flippers, more than doubling their welfare.

Table 12: Comparison

Variable	**% Change**	
	Change in f	**Change in λ**
Mean Price	-1.51	-1.47
Var Price	-0.31	-3.54
Flipper Share	67.42	279.04
HH Trade	-7.95	-13.56
Total Trade	5.16	6.67
Return	0.99	1.39
Turnover	5.16	6.67
Welfare pc		
Total	-2.44	1.34
Households	-0.20	0.17
Homeowners	0.34	0.43
Non-Homeowners	3.02	2.49
Flipper	-23.43	147.15
Misallocation		
Total	-5.22	-8.42
Owners	-3.03	-7.28
Non-Owners	-7.36	-9.54

Note: Comparison counterfactual changes in f and λ which induce equivalent meeting with flipper rates

5.6 Policy - sales tax on flippers

Policy of interest is sales tax on houses.
Before 2011 Ireland had 9% sales tax rate on houses other than household main residence.
This tax especially targets flipped transaction.
Using our model we determine effects of that relatively high tax rate on flipping activity, prices, quantities and welfare.
What is evident from Table 13 this experiment is that nearly 60% of trade facilitated by flippers disapears and it accounts for 70% of welfare loss per flipper.
Trade volume effect in this exercise is underestimating the effect when we allow for free entry decision of flippers as response to tax policy.

Table 13: Results of Counterfactual Introduction of Sales Tax on Flipping $\tau = 0.09$

Variable	**% Change**
Mean Price	0.71
Var Price	4.51
Flipper Share	-54.81
HH Trade	3.60
Total Trade	-3.30
Return	4.59
Turnover	-3.30
Welfare pc	
Total	-0.43
Households	-0.01
Homeowners	-0.22
Non-Homeowners	-1.88
Flipper	-53.32
Misallocation	
Total	2.77
Owners	1.82
Non-Owners	3.69

Note:

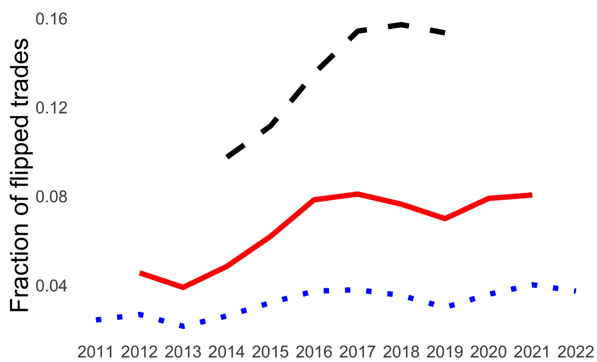
6 Robustness and Validation

6.1 Different definitions of flipping

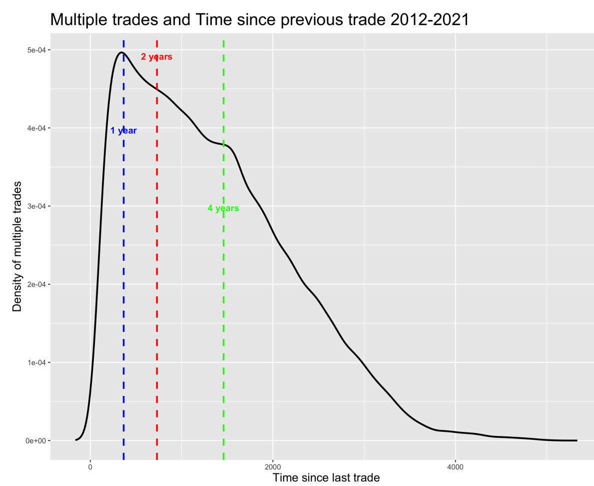
Figure 13 considers different definitions of time window between two leg transactions to identify flipped transactions. Left panel shows levels of flipping across time for different time difference between transaction - 1 year (blue), 2 year (red) and 4 years (black). For either of those definition we observe increase in fraction of flipped trades across span of sample. Right panel presents pdf of time differences between multiple trades (as function of time on x axis). Red dotted line marks time definition of flipping between trades used in main body of this paper. That distribution spikes at 1 year (blue) and has bunches at 4 years(green).

Figure 13: Different time definitions of flipping

(a) Time trends



(b) PDF of all multiple trades



Note: Left panel shows levels of flipping across time for different time difference between transaction - 1 year (blue), 2 year (red) and 4 years (black).
For either of those definition we observe increase in fraction of flipped trades across span of sample.
Right panel presents pdf of time differences between multiple trades (as function of time on x axis).
Red dotted line marks time definition of flipping between trades used in main body of this paper.
That distribution spikes at 1 year (blue) and has bunches at 4 years(green).

6.2 Data validation

How good is data set used in 3 in matching price indexes- common for literature on house price indexes test ? Figure 14 considers that. On left panel green line uses transaction data from 3 - it takes pairs of houses transacted which are not flipped[32] between 2010

[32] with restricting at 90 days from below between trade- common Case-Shiller condition

Table 14: Alternative definitions of flipping- **UPDATE THIS at the end- shared is differently calculated**

	1 year		**2 years (baseline)**		**4 years**	
f	0.009		0.0021		0.013	
γ	0.09		0.07		0.09	
ρ	0.3		0.3		0.3	
λ	3.0		3.0		5.0	
	Model	Data	Model	Data	Model	Data
Fraction of flipped	2.53%	2.44%	4.81%	4.56%	9.27%	9.75%
Mean price	11.98	12.88	11.62	11.42	11.85	12.54
Return on flipping	122.73%	111.29%	126.96%	129.33%	123.35%	151.41%
Tenure time	2.72%	5.59%	2.54%	5.59%	2.86%	5.59%
Loss function	0.28		0.30		0.28	
	Main Counterfactual % Change					
Mean Price	-2.34		-1.51		-2.53	
Var Price	0.70		-0.31		-0.07	
Flipper Share	240.90		67.42		104.13	
HH Trade	-10.28		-7.95		-16.50	
Total Trade	10.62		5.16		12.50	
Return	0.90		0.99		1.45	
Turnover	10.62		5.16		12.50	
Welfare pc						
Total	-3.38		-2.44		-2.58	
Household	-0.41		-0.20		-0.52	
Homeowners	0.38		0.34		0.54	
Non-Homeowners	5.49		3.02		5.53	
Flipper	-29.41		-23.43		-32.67	
Misallocation						
Total	-7.16		-5.22		-10.51	
Owners	-4.18		-3.03		-6.59	
Non-Owners	-10.02		-7.36		-14.34	

Note: Table contains alternative time windows for defining flipped transactions. For 1 year (2 years; 4 years) definition between trades, model was estimated to target 2011 (2012; 2014) moments from data. Counterfactual was done for 1 year (2 years; 4 years) to match share of flipped transactions in 2022 (2021; 2019).

and 2021 and calculates rate of change for each year using expenditure weights. Violet line is Case-Shiller type index reported by Central Statistics Office Ireland (CSO). The

Table 15: Untargeted moment: prices and intermediation

	1 Years	2 Year	4 Years
		Data	
Year	2011	2012	2014
β	-0.19	-0.21	-0.08
		Model	
β	-0.22	-0.29	-0.15

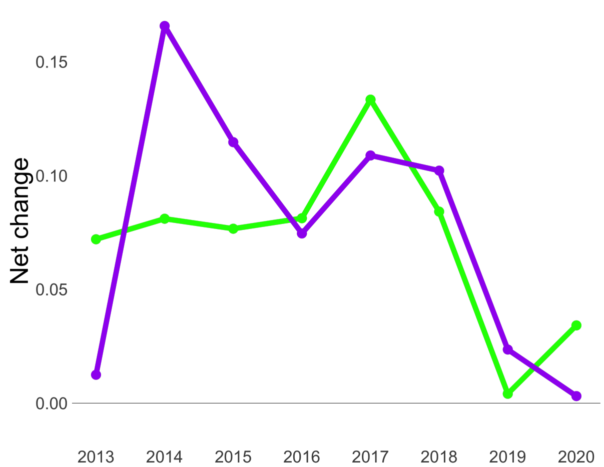
Note: $T = 100$, burn in 20 periods with $N = 10000$

difference in those samples comes from fact that statistical office can identify trades in past making price index depend on more observations- repeated sales. My data in early years of sample does not have too many observations by construction and in that part of figure rates of change in HPIs don't match well. Later on, post 2015 two curves are similar in shape and behavior. In constructing green sample we took conservative stance on flipped transaction assuming that all those trades change quality of housing in important way therefore excluding it from constant quality HPI.

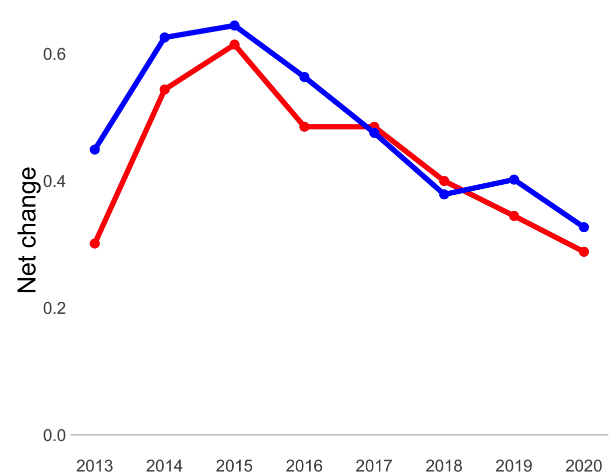
What would be behavior of house price index when we don't exclude flippers? Right panel of Figure 14 presents unweighted (red) and expenditure weighted HPI[33] presents behavior of changes in HPI between years when we add flipped transactions.

Figure 14: Price indexes- Data Validation

(a) Data vs Statistical Office (CSO) changes in HPI



(b) Changes of HPI calculated including all flipped trades



Note:

[33] **HERE THINK about quality**

7 Conclusion

Appendix

.1 Derivation of the model

Timing

Morning t: Household (q, δ) wakes up with asset position $q \in \{0, 1\}$ and type $\delta \in [0, 1]$. Then

1. price is offered $P_t(1-q)$
2. λ trade opportunity arrives [34].
3. conditional on meeting accept/reject prices $A_t(\delta, q; P^t)$
4. γ shock to type arrives
5. payoffs are realized: flow is paid $q\delta\Delta$
6. **evening** discounts with $e^{-r\Delta}$
7. move to $t + \Delta$

History of shocks γ, λ can be recovered from (δ, q) **Notation**

- Household of type (q, δ) conditional on vector of prices $P^t = \{P_s(1-q)\}_t^\infty$ decides about $A_t : (q, \delta; P^t) \to \{A, R\}$
- Flipper of type q conditional on decision rule $A^t = \{\{A_s(1-q, \delta; P^s)\}_{\delta \in G}\}_t^\infty$ decides price P_t

Definition 5 (Symmetric Markov Perfect Equilibrium). *consists of*

1. *value functions* $V_t : (q, \delta; P^t) \to \mathbb{R}$, $W_t : (q; A^t) \to \mathbb{R}$
2. *decision rules* $A_t(\delta, q; P^t) \to \{A, R\}$
3. *prices* $P_t : (q; A^t) \to \mathbb{R}_+$
4. *distributions :* $H_t : (q, \delta) \to \mathbb{R}$, $F_t : (q) \to \mathbb{R}$

- *Given prices P^t : value functions V_t and A_t solve household problem (given by HJB equation)*
- *Given decision rule of hh A^t : value functions W_t and prices P_t solve flipper problem (given by HJB equations)*

[34] γ, λ independent with each other and exponential

- *Low of motions hold , Accounting hold*
- *In equilibrium* $A_t(q,\delta;P^t) = A(q,\delta;P(1-q))$, $P_t(q) = P(q)$ *and satisfy ICs*

Take $\Delta \to 0$ after that **Household's problem** Household of type (δ, q) conditional on vector of prices $P^t = \{P_s(1-q)\}_t^\infty$ and decides about $A_t : (\delta, q; P^t) \to \{A, R\}$ by solving

$$V_t(q,\delta;P^t) = \max_{A_t \in \{A,R\}} q\delta\Delta + \gamma\Delta(1-\lambda\Delta)\int_0^1 V_t(q,\delta';P^t)dG(\delta')+$$

$$+(1-\gamma\Delta)\lambda\Delta \max\{\underbrace{e^{-r\Delta}V_{t+\Delta}(q,\delta;P^{t+\Delta})}_{A_t=R},$$

$$\underbrace{(2q-1)P_t(1-q)+e^{-r\Delta}V_{t+\Delta}(1-q,\delta;P^{t+\Delta})}_{A_t=A}\}+]$$

$$+(1-\gamma\Delta)(1-\lambda\Delta)e^{-r\Delta}V_{t+\Delta}(q,\delta;P^{t+\Delta})+$$

$$+\gamma\Delta\lambda\Delta\int_0^1 \max\{\underbrace{e^{-r\Delta}V_{t+\Delta}(q,\delta';P^{t+\Delta})}_{A_t=R},$$

$$\underbrace{(2q-1)P_t(1-q)+e^{-r\Delta}V_{t+\Delta}(1-q,\delta';P^{t+\Delta})}_{A_t=A}\}dG(\delta')]$$

Define $\Delta V_t(\delta;P^t) = V_t(1,\delta,1;P^t) - V_t(0,\delta;P^t)$. Subtract $e^{-r\Delta}V_t(q,\delta;P^t)$, divide by Δ to get:

$$\frac{1-e^{-r\Delta}}{\Delta}V_t(\delta,q;P^t) = \max_{A_t} q\delta + e^{-r\Delta}\frac{V_{t+\Delta}(q,\delta;P^{t+\Delta}) - V_t(q,\delta;P^t)}{\Delta}$$

$$+e^{-r\Delta}[\gamma(1-\lambda\Delta)\int_0^1[V_t(\delta',q;P^t) - e^{-r\Delta}V_t(\delta,q;P^t)]dG(\delta')+$$

$$+(1-\gamma\Delta)\lambda\max\{0,(2q-1)[P_t(1-q)-e^{-r\Delta}\Delta V_{t+\Delta}(\delta,;P_{t+\Delta})]\}+o(\Delta)]$$

Flipper's problem Given decision rule of agents A^t Flipper of type q chooses P_t to solve

$$W_t(q,A^t) = \max_{P_t}\lambda\Delta\int_0^1 \mathbb{1}[\delta : A_t(1-q,\delta,P^t) = A]\cdot$$

$$\cdot\max\{(2q-1)P_t + e^{-r\Delta}W_{t+\Delta}(q,A^{t+\Delta}), e^{-r\Delta}W_{t+\Delta}(1-q,A^{t+\Delta})\}dH_t(1-q,\delta)$$

$$+\cdots+\cdots$$

becomes

$$\frac{1-e^{-r\Delta}}{\Delta}W_t(q,A^t) = \max_{P_t} e^{-r\Delta}\frac{W_{t+\Delta}(q,A^{t+\Delta}) - W_t(q,A^{t+\Delta})}{\Delta}+$$

$$+\lambda\Delta\int_0^1 \mathbb{1}[\delta : A^t(1-q,\delta,P^t) = A]\cdot$$

$$\cdot\max\{0,(2q-1)[P_t + e^{-r\Delta}\Delta W_{t+\Delta}(q,A^{t+\Delta}))\}dH_t(\delta^t,(1-q_t)\times q^t) + o(\Delta) + o(\Delta)$$

Reservation values=cutoffs

- Define a cutoff δ_q^*

$$\delta_q^*(P^t) = \mathbb{1}[\delta : A_t(q,\delta;P^t) = A]$$

- Easy to show: decision monotone in type δ
- Moreover in equilibrium flipper proposes price which is always accepted
- then

$$P_t(1-q) = e^{-r\Delta}\Delta V_{t+\Delta}(\delta^*(q,P_t(1-q));P^{t+\Delta})$$

Envelope

$$P_t(1-q) = e^{-r\Delta}\Delta V_{t+\Delta}(\delta_q^*(P^t);P_{t+\Delta})$$

Suppose that ΔV is differentiable at cutoff [35] and differentiate wrt $P_t(1-q)$

$$1 = e^{-r\Delta}\frac{\partial}{\partial\delta}\Delta V_{t+\Delta}(\delta_q^*(P^t);P_{t+\Delta})\frac{d}{dP}\delta_q^*(P^t)$$

impose stationarity and take limit $\Delta \to 0$

$$1 = \Delta V'(\delta_q^*(P(1-q));P(1-q))\cdot\delta_q^{*'}(P(1-q))$$

Bottom line: Future prices don't enter current cutoff! Therefore perturbation around current price is all that matter.

Here I took t limit without imposing stationarity but I am ilustrating-UPDATE THIS in proof I use continuity of ΔV at cutoffs and I notice that

$$P_t(1-q) = \frac{\delta_q^*(P^t) + \gamma\int_0^1 \Delta V(q,\delta')dG(\delta')}{r+\gamma}$$

bc there is no trade at each cutoff, together:

$$P_t(1) - P_t(0) = \frac{\delta_0^*(P_t(1)) - \delta_1^*(P_t(0))}{r+\gamma}$$

then assuming that cutoffs are differentiable we find that

[35] it is not! details next slide

$$\delta_0^{*'}(P_t(1)) = \delta_1^{*'}(P_t(0)) = r + \gamma$$

.2 Balance of trade

In order to get balance of trade condition from law of motions for households to the following: Differentiate (**??**) (and abuse $d\delta$ notation):

$$dH(0,\delta) + dH(1,\delta) = G'(\delta)d\delta = 1$$

Rearange and differentiate (**??**) at the interior of intervals (holds for $\delta \neq \delta_1^*, \delta_0^*$ to get

$$\mathbb{1}\{\delta \geq \delta_0^*\}[\lambda F(1) dH(0,\delta)] + \gamma \underbrace{G'(\delta)}_{1} \int_0^{\bar{\delta}} dH(1,\delta) = \tag{16}$$

$$= \mathbb{1}\{\delta \leq \delta_1^*\}[\lambda F(0) dH(1,\delta)] + \gamma dH(1,\delta) \tag{17}$$

Integrate over δ on $[0, \bar{\delta}]$ to get flippers (inflow= outflow) condition:

$$F(1) \int_{\delta_0^*}^{\bar{\delta}} dH(0,\delta) = F(0) \int_0^{\delta_1^*} dH(1,\delta) \tag{18}$$

.3 Characterization of H, F

Now let's look at (16) and let's rearrange it

$$\mathbb{1}\{\delta \geq \delta_0^*\}[\lambda F(1) \underbrace{dH(0,\delta)}_{1-dH(1,\delta)}] + \gamma \underbrace{\int_0^{\bar{\delta}} dH(1,\delta)}_{s-F(1)} =$$

$$= \mathbb{1}\{\delta \leq \delta_1^*\}[\lambda \underbrace{F(0)}_{f-F(1)} dH(1,\delta)] + \gamma dH(1,\delta)$$

$$\lambda F(1) \mathbb{1}\{\delta \geq \delta_0^*\} + \gamma(s - F(1)) = dH(1,\delta) \cdot [\lambda(f - F(1)) \mathbb{1}\{\delta \leq \delta_1^*\} + \gamma + \lambda F(1) \mathbb{1}\{\delta \geq \delta_0^*\}] \tag{19}$$

which holds for $\delta \neq \delta_1^*, \delta_0^*$.

.4 Solving for H, F

1. $\delta < \delta_1^* < \delta_0^*$

$$\gamma(s - F(1)) = dH(1,\delta) \cdot [\lambda(f - F(1)) + \gamma]$$

$$dH^1(1,\delta) = \frac{\gamma(s - F(1))}{\lambda(f - F(1)) + \gamma}$$

2. $\delta_1^* < \delta < \delta_0^*$

$$\gamma(s - F(1)) = dH(1,\delta) \cdot [\gamma]$$

$$dH^2(1,\delta) = s - F(1)$$

3. $\delta_1^* < \delta_0^* < \delta$

$$\lambda F(1) + \gamma(s - F(1)) = dH(1,\delta) \cdot [\gamma + \lambda F(1)]$$

$$dH^3(1,\delta) = \frac{\lambda F(1) + \gamma(s - F(1))}{\gamma + \lambda F(1)}$$

$$F(1)\int_{\delta_0^*}^{\bar{\delta}} (1 - dH^3(1,\delta)) = (f - F(1))\int_0^{\delta_1^*} dH^1(1,\delta)$$

Claim 1. *For all parameters there exists a pair :* $\{F(1), F(0)\}, \{dH(0,\delta), dH(1,\delta)\} \in [0,1]^2$ *such that* $F(1) + F(0) = f$ *and* $\int_0^{\hat{\delta}} dH(0,\delta) + dH(1,\delta) = G(\hat{\delta})$

A Proof of existence $F(0), F(1) \in [0, \min\{s, f\}]$

Define polinominal of degree 3, argue that under $\lambda > \gamma$ it's third order term enters with negative number, $!\exists F(1) \in [0,s]$ and show that the same holds for $F(0)$

Because $dH(0,\delta)$ is constant on $[\delta_0^*, \bar{\delta}]$ and $dH(1,\delta)$ is constant on $[0, \delta_1^*]$interval we have

$$F(1)(\bar{\delta} - \delta_0^*)dH(0,\delta_0^*) = F(0)\delta_1^* dH(1,\delta_1^*)$$

From 19 and keeping in mind that trade happens at the cuttoffs as well

$$dH(1,\delta_1^*) = \frac{\gamma(s - F(1))}{\lambda(f - F(1)) + \gamma}$$

$$dH(0,\delta_0^*) = \frac{\gamma(1 - s + F(1))}{\gamma + \lambda F(1)}$$

define

$$g(x) = x(\bar{\delta} - \delta_0^*)(1 - s + x)(\lambda(f - x) + \gamma) - (f - x)\delta_1^*(s - x)(\lambda x + \gamma)$$

$$h(x) = (f - x)(\bar{\delta} - \delta_0^*)(1 - s - f + x)(\lambda x + \gamma) - x\delta_1^*(s - f + x)(\lambda f - \lambda x + \gamma)$$

$$g(0) = -f\delta_1^* s\gamma < 0$$

Assume that $f < s$, $s + f < 1$

$$g(f) = f(\bar{\delta} - \delta_0^*)(1 - s - f)\gamma$$

So there is a root ($F(1)$) on $(0, f)$ from IVThm. Now for $F(0)$:

$$h(0) = f(\bar{\delta} - \delta_0^*)(1 - s - f)(\gamma) > 0$$

$$h(f) = 0 - f\delta_1^* s\gamma < 0$$

so there is root $F(0)$ in $(0, f)$ as well.

A.1 Value functions

Fix intervals

Household's problem

$$rV(0,\delta) = \gamma \int_0^{\bar{\delta}} [V(0,\delta') - V(0,\delta)]dG(\delta') + \lambda F(1) \max\{-P_1 + V(1,\delta) - V(0,\delta), 0\}$$

$$rV(1,\delta) = \delta + \gamma \int_0^{\bar{\delta}} [V(1,\delta') - V(1,\delta)]dG(\delta') + \lambda F(0) \cdot \max\{P_0 + V(0,\delta) - V(1,\delta), 0\}$$

Consider three cases

1. $\delta < \delta_1^* < \delta_0^*$ In this case non owner buys $V(0,\delta)$ and owner does not participate in trade $V(1,\delta)$

$$V(0,\delta) = \frac{\gamma}{r+\gamma} \int_0^{\bar{\delta}} V(0,\delta')dG(\delta')$$

$$V(1,\delta) = \frac{\delta}{r+\gamma+\lambda F(0)} + \gamma \int_0^{\bar{\delta}} V(1,\delta')dG(\delta') + \frac{\lambda F(0)}{r+\gamma+\lambda F(0)}(P_0 + V(0,\delta))$$

2. $\delta_1^* < \delta < \delta_0^*$ This is inaction region neither household homeowner nor non owner trades when facing trade opportunity

$$V(0,\delta) = \frac{\gamma}{r+\gamma} \int_0^{\bar{\delta}} V(0,\delta')dG(\delta')$$

$$V(1,\delta) = \frac{\delta}{r+\gamma} + \frac{\gamma}{r+\gamma} \int_0^{\bar{\delta}} V(1,\delta')dG(\delta')$$

3. $\delta_1^* < \delta_0^* < \delta$ In this case owner sells

$$V(0,\delta) = \frac{\gamma}{r+\gamma+\lambda F(1)} \int_0^{\bar{\delta}} V(0,\delta')dG(\delta') + \frac{\lambda F(1)}{r+\gamma+\lambda F(1)}(-P_1 + V(1,\delta))$$

$$V(1,\delta) = \frac{\delta}{r+\gamma} + \frac{\gamma}{r+\gamma} \int_0^{\bar{\delta}} V(1,\delta')dG(\delta')$$

Value functions have kinks at cutoffs ($V(1,\delta_1^*)$ and $V(1,\delta_1^*)$) but they are continuous functions. Calculate reservation value of each of three cases

$$\Delta V(\delta) = V(1,\delta) - V(0,\delta)$$

1. $\delta < \delta_1^* < \delta_0^*$

$$\Delta V(\delta) = \frac{\delta + \gamma \int_0^{\bar{\delta}} \Delta V(\delta')dG(\delta') + \lambda F(0)P_0}{r+\gamma+\lambda F(0)}$$

2. $\delta_1^* < \delta < \delta_0^*$

$$\Delta V(\delta) = \frac{\delta + \gamma \int_0^{\bar{\delta}} \Delta V(\delta')dG(\delta')}{r+\gamma}$$

3. $\delta_1^* < \delta_0^* < \delta$

$$\Delta V(\delta) = \frac{\delta + \gamma \int_0^{\bar{\delta}} \Delta V(\delta')dG(\delta') + \lambda F(1)P_1}{r+\gamma+\lambda F(1)}$$

Notice that value functions are piecewise linear on relevant intervals with following slopes (notice that value functions are non differentiable at kinks) :

$$\frac{dV(0,\delta)}{d\delta} = \begin{cases} 0 & \text{if} \delta \in [0,\delta_0) \\ \frac{\lambda F(1)}{(r+\gamma)(r+\gamma+\lambda F(1))} & \text{if} \delta \in (\delta_0, \bar{\delta}] \end{cases}$$

$$\frac{dV(1,\delta)}{d\delta} = \begin{cases} \frac{1}{r+\gamma+\lambda F(1)} & \text{if} \delta \in [0,\delta_1) \\ \frac{1}{r+\gamma} & \text{if} \delta \in (\delta_1, \bar{\delta}] \end{cases}$$

$$\frac{d\Delta V(\delta)}{d\delta} = \begin{cases} \frac{\lambda F(1)}{(r+\gamma)(r+\gamma+\lambda F(1))} & \text{if} \delta \in (\delta_1, \bar{\delta}) \\ \frac{1}{r+\gamma} & \text{if} \delta \in (\delta_1, \delta_0) \\ \frac{\lambda F(1)}{(r+\gamma)(r+\gamma+\lambda F(1))} & \text{if} \delta \in (\delta_1, \bar{\delta}] \end{cases}$$

Set $\mathbb{E}\Delta V := \int_0^{\bar{\delta}} \Delta V(\delta')dG(\delta')$.

Prices are such that agent a cutoff has zero reservation value then:

$$P_1 = \Delta V(\delta_0^*) = \frac{\delta_0^* + \gamma \mathbb{E}\Delta V}{r+\gamma}$$

$$P_0 = \Delta V(\delta_1^*) = \frac{\delta_1^* + \gamma \mathbb{E}\Delta V}{r+\gamma}$$

then

$$P_1 - P_0 = \frac{\delta_0^* - \delta_1^*}{r+\gamma} \tag{20}$$

keep in mind that cutoffs are functions of prices (because price offers are observed by agents first when deciding about trade cutoff) so $\delta_0^*(P_1)$,$\delta_1^*(P_0)$. Assuming differentiability of cuttoffs with respect in equation 20 to prices we get

$$\delta_1^{*\prime}(P_0) = \delta_0^{*\prime}(P_1) = r+\gamma$$

Flipper's problem

$$rW(0) = \max_{P_0} \lambda \int_0^{\delta_1^*(P_0)} dH(1,\delta)[-P_0 + W(1) - W(0)]$$

$$rW(1) = \max_{P_1} \lambda \int_{\delta_0^*(P_1)}^{\bar{\delta}} dH(0,\delta)[P_1 + W(0) - W(1)]$$

Optimal price choice- perturbation differentiate wrt $P(0)$ and $P(1)$ respectively to get:

$$0 = \underbrace{\int_{\delta_0^*(P_1)}^{\bar{\delta}} dH(0,\delta)}_{\text{MB to } F(1) \text{from charging more}} - \underbrace{[P_1 + W(0) - W(1)] \cdot \delta_0^{\prime *}(P(1)) \cdot dH(0, \delta_0^*(P_1))}_{\text{MC to } F(1) \text{from changing cuttoff today}}$$

$$0 = \underbrace{\int_0^{\delta_1^*(P_0)} dH(1,\delta)}_{\text{MB to } F(1) \text{from charging less}} + \underbrace{[-P_0 + W(1) - W(0)] \cdot \delta_1^{\prime *}(P_0) \cdot dH(1, \delta_1^*(P_0))}_{\text{MC to } F(1) \text{from changing cuttoff today}}$$

Because $dH(0,\delta)$ is constant on $[\delta_0^*, \bar{\delta}]$ and $dH(1,\delta)$ is constant on $[0, \delta_1^*]$interval we have

$$\int_0^{\delta_1^*(P_0)} dH(1,\delta) = \delta_1^*(P_0) dH(1, \delta_1^*(P_0)) = \delta_1^{*\prime}(P_0) dH(1, \delta_1^*(P_0))(-P_0 + W(1) - W(0))$$

$$\int_{\delta_0^*(P_1)}^{\bar{\delta}} dH(0,\delta) = (\delta_0^*(P_1) - \bar{\delta}) dH(0, \delta_0^*(P_1)) = \delta_0^{*\prime}(P_1) dH(0, \delta_0^*(P_1))(-P_1 + W(0) - W(1))$$

$$\frac{\delta_1^*(P_0)}{\delta_1^{*\prime}(P_0)} = -P_0 + W(1) - W(0)$$

$$\frac{\bar{\delta} - \delta_0^*(P_1)}{\delta_0^{*\prime}(P_1)} = P_1 + W(0) - W(1)$$

sum those two to get

$$\frac{\bar{\delta} - \delta_0^*(P_1) + \delta_1^*(P_0)}{r+f} = \frac{P_1 - P_0}{r+f} = \delta_0^*(P_1) - \delta_1^*(P_0)$$

$\bar{\delta} = 1$ so:

$$\frac{1}{2} = \delta_0^*(P_1) - \delta_1^*(P_0)$$

Now plug stuff back to original problem to get $W(1), W(0)$:

$$W(0) = \frac{\lambda(\delta_1^*)^2}{r(r+\gamma)} dH(,\delta_1^*)$$

$$W(1) = \frac{\lambda(1-\delta_0^*)^2}{r(r+\gamma)} dH(0,\delta_0^*)$$

One more step using flipper probelm to get iterative (monotone) sequence - type the proof idea :constant is negative, contraction and $dH < 1$

$$\delta_1^* = -\frac{\gamma}{2}\mathbb{E}\Delta V + \frac{\lambda}{2r}[(1-\delta_0^*)^2 dH(0,\delta_0^*) - (\delta_1^*)^2 dH(1,\delta_1^*)]$$
$$\delta_0^* = \frac{1}{2} - \frac{\gamma}{2}\mathbb{E}\Delta V + \frac{\lambda}{2r}[(1-\delta_0^*)^2 dH(0,\delta_0^*) - (\delta_1^*)^2 dH(1,\delta_1^*)]$$

A.2 Code

Clean this up

All functions in code are have as last arguments $\gamma, \lambda\_, s, f, r$ and some other variables.

For fixed $\delta_0^*, \delta_1^*, F(1)$ we define function $dH1\_\text{comp}$ as:

$$dH(1,\delta) = \frac{\lambda F(1)\mathbb{1}\{\delta \geq \delta_0^*\} + \gamma(s - F(1))}{\lambda(f - F(1))\mathbb{1}\{\delta \leq \delta_1^*\} + \gamma + \lambda F(1)\mathbb{1}\{\delta \geq \delta_0^*\}}$$

we define function solve_$F1$ which finds $F(1)$ given δ_0^*, δ_1^* using:

$$F(1)\int_{\delta_0^*}^{\bar{\delta}}(1-dH(1,\delta)=(f-F(1))\int_0^{\delta_1^*}dH(1,\delta)$$

we define function $F1$ which has values of solve_$F1$.
then we define function $dH1$ and plug back $dH(1,\delta)$ and define function $dH0$ and calculate $dH(0,\delta)$as:

$$dH(0,\delta)=1-dH(1,\delta)$$

and we define function $F0$ which calculates $F(0)$ as

$$F(0)=f-F(1)$$

Now for fixed δ_0^*, δ_1^* we define function value_function that solves for $V(0,\delta), V(1,\delta)$ using value function iterations (expression on right hand side is n-th iteration and expression on right defines n+1 iteration). Interpolate value functions on grid of $\delta \in [0,\bar{\delta}]$ as well to find prices, when you calculate iterations

$$\delta \le \delta_0^* \quad V(0,\delta)=\frac{\gamma}{r+\gamma}\int_0^{\bar{\delta}}V(0,\delta')dG(\delta')$$

$$\delta > \delta_0^* \quad V(0,\delta)=\frac{\gamma}{r+\gamma+\lambda F(1)}\int_0^{\bar{\delta}}V(0,\delta')dG(\delta')+\frac{\lambda F(1)}{r+\gamma+\lambda F(1)}[-P(1)+V(1,\delta)]$$

$$\delta < \delta_1^* \quad V(1,\delta)=\frac{\delta}{r+\gamma+\lambda(f-F(1))}+\frac{\gamma}{r+\gamma+\lambda(f-F(1))}\int_0^{\bar{\delta}}V(1,\delta')dG(\delta')+$$

$$+\frac{\lambda(f-F(1))}{r+\gamma+\lambda(f-F(1))}[P(0)+V(0,\delta)-V(1,\delta)]$$

$$\delta \ge \delta_1^* \quad V(1,\delta)=\frac{\delta}{r+\gamma}+\frac{\gamma}{r+\gamma}\int_0^{\bar{\delta}}V(1,\delta')dG(\delta')$$

we define function $P0$:

$$P(0)=V(1,\delta_1^*)-V(0,\delta_1^*)$$

we define function $P1$:

$$P(1)=V(1,\delta_0^*)-V(0,\delta_0^*)$$

Update cuttofs by using following reqursion

$$\delta_1^{new}=-\frac{\gamma}{2}\mathbb{E}\Delta V^n+\frac{\lambda}{2r}[(1-\delta_0^n)^2 dH(0,\delta_0^n)-(\delta_1^n)^2 dH(1,\delta_1^n)]$$

$$\delta_0^{new}=\frac{1}{2}-\frac{\gamma}{2}\mathbb{E}\Delta V^n+\frac{\lambda}{2r}[(1-\delta_0^n)^2 dH(0,\delta_0^n)-(\delta_1^n)^2 dH(1,\delta_1^n)]$$

And get $n+1$ iteration using relaxation parameter $\chi = \min\{\frac{1}{\gamma}, \frac{r}{\lambda}\}$:

$$\delta_i^{n+1} = \chi\delta_i^{new} + (1-\chi)\delta_i^n$$

Type it up. $\delta_1 = -\frac{\gamma}{2}\mathbb{E}\Delta V(\cdot) + \dots$

A.3 Algorithm- Flipper with Household trade only

Rewrite it by looking at proof and code (more detail)

1. For n-th iteration of cutoffs δ_0^n, δ_1^n
2. Solve for distributions $H^n(q,\cdot), F^n(q)$ using accountings and LOMs
3. Solve for $V^n(q)$ using $\delta_q^n, F^n(q)$ from value functions . Find prices $P^n(q)$
4. Solve for $W^n(q)$ using $\delta_q^n, H^n(q,\cdot)$
5. Update to $n+1$ iteration of $\delta_0^{n+1}, \delta_1^{n+1}$

A.4 Algorithm

Solving the model requires solving value function problem for every cutoff and finding cutoffs. Let's start with latter. Using value function condition at cutoff δ_0 combined with value functions for flippers with it's equilibrium condition allows us to express delta explicitly as function of value functions and distributions. This way we can introduce next iteration using current iteration functions as:

$$\delta_0^{n+1} = \sigma^n(\delta_0^n)[(1+\frac{r}{\lambda}\frac{1}{H^n(0,1)-H^n(0,\delta_0^n)})W^n(1) - W^n(0)] -$$
$$-\frac{\rho}{2}\int_{\delta_0^n}^1 \Delta V^n(\delta')dH^n(0,\delta') - \frac{\rho}{2}\int_0^{\delta_0^n} \Delta V^n(\delta')dH^n(1,\delta') - \gamma\int_0^1 \Delta V^n(\delta')dG(\delta')$$
$$\delta_1^{n+1} = \sigma^n(\delta_1^n)[W^n(1) - (1+\frac{r}{\lambda}\frac{1}{H^n(1,\delta_1^n)})W^n(0)] -$$
$$-\frac{\rho}{2}\int_{\delta_1^n}^1 \Delta V^n(\delta')dH^n(0,\delta') - \frac{\rho}{2}\int_0^{\delta_1^n} \Delta V^n(\delta')dH^n(1,\delta') - \gamma\int_0^1 \Delta V^n(\delta')dG(\delta')$$

We look at error (lhs minus rhs) of those expressions to find a fixed point. Existence of those cutoffs comes from proposition from section 2 and proof of existance of reservation value from

Hugonnier et al. (2020). To solve for value functions observe that integration is linear operator which allows us to use matrix representation of a problem.

Write it in matrix form for grid on delta vector (denoted by Y)

$$Y = [\delta^0, \delta^1, \dots, \delta^{end}]$$

and for vectors

$$X_n = [\Delta V_n(\delta^0), \Delta V_n(\delta^1), \dots, \Delta V_n(\delta^{end})]$$

as $X_n^{\delta_1} = \Delta V_n(\delta^1)$ $X_n^{\delta_0} = \Delta V_n(\delta^0)$ and Σ ,$dH0\Delta$,$dH1\Delta$ are matrices we calculated in our code. We can write in matrix form

$$\Sigma X_{n+1} = Y + \gamma dG \otimes \mathbf{1}^T \lambda F(0) X_n^{\delta_1} \mathbb{1}[\delta_1 > \delta^i] + \lambda F(1) X_n^{\delta_0} \mathbb{1}[\delta_0 < \delta^i] + \frac{\rho}{2} dH0\Delta + \frac{\rho}{2} dH1\Delta$$

which becomes

$$X_{n+1} = [Y + \lambda F(0) X_n^{\delta_1} \mathbb{1}[\delta_1 > \delta^i] + \lambda F(1) X_n^{\delta_0} \mathbb{1}[\delta_0 < \delta^i]][\Sigma - \gamma dG \otimes \mathbf{1}^T - \frac{\rho}{2} dH0\Delta - \frac{\rho}{2} dH1\Delta]^{-1}$$

therefore we do value iteration

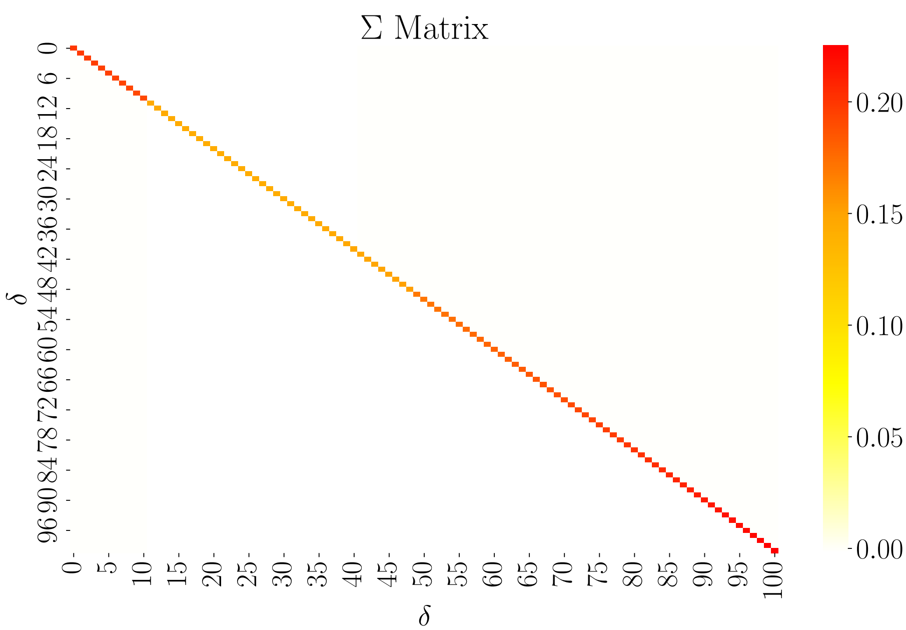


Table 16: Regression Results with Different Fixed Effects

	(1)	(2)	(3)	(4)	(5)
Location FE	County	City	District	City	District
Quarter-Year FE	$\times$	$\times$	$\times$	✓	✓
Constant	12.16***	12.16***	12.19***	12.16***	12.18***
	(0.0008)	(0.0008)	(0.0007)	(0.0008)	(0.0007)
Observations	638,751	638,751	561,010	629,920	532,097
R-squared	0.273	0.378	0.550	0.426	0.566

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

A.5 Algorithm quantitative model

Write it in matrix form for grid on delta vector (denoted by Y)

$$Y = [\delta^0, \delta^1, \dots, \delta^{end}]$$

and for vectors

$$X_n = [\Delta V_n(\delta^0), \Delta V_n(\delta^1), \dots, \Delta V_n(\delta^{end})]$$

as $X_n^{\delta_1} = \Delta V_n(\delta^1)$ $X_n^{\delta_0} = \Delta V_n(\delta^0)$ and Σ ,$dH0\Delta$,$dH1\Delta$ are matrices we calculated in our code. We can write in matrix form

$$\Sigma X_{n+1} = Y + \gamma dG \otimes \mathbf{1}^T \lambda F(0) X_n^{\delta_1} \mathbb{1}[\delta_1 > \delta^i] + \lambda F(1) X_n^{\delta_0} \mathbb{1}[\delta_0 < \delta^i] + \frac{\rho}{2} dH0\Delta + \frac{\rho}{2} dH1\Delta$$

which becomes

$$X_{n+1} = [Y + \lambda F(0) X_n^{\delta_1} \mathbb{1}[\delta_1 > \delta^i] + \lambda F(1) X_n^{\delta_0} \mathbb{1}[\delta_0 < \delta^i]][\Sigma - \gamma dG \otimes \mathbf{1}^T - \frac{\rho}{2} dH0\Delta - \frac{\rho}{2} dH1\Delta]^{-1}$$

therefore we do value iteration

$$V^{n+1}(1,\delta) = \frac{\delta}{r+\gamma} + \frac{\gamma}{r+\gamma} \int_0^{\bar{\delta}} V^n(1,\delta') dG(\delta') + \frac{\lambda}{r+\gamma} F(0)(\Delta V(\delta_1) - \Delta V(\delta)) \mathbb{1}[\delta < \delta_1] +$$

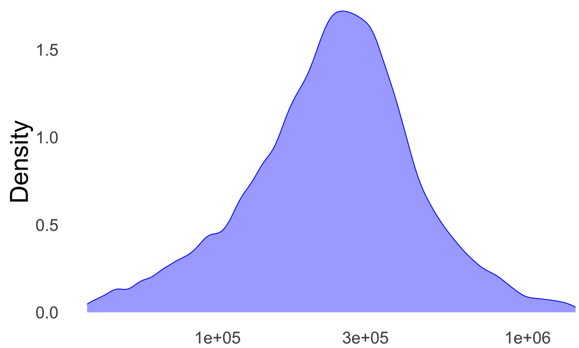
$$+ \frac{\rho}{r+\gamma} \int_{\delta}^{\bar{\delta}} \frac{1}{2} [\Delta V(\delta') - \Delta V(\delta)] dH(0,\delta')$$

$$V^{n+1}(0,\delta) = \frac{\gamma}{r+\gamma} \int_0^{\bar{\delta}} V^n(0,\delta') dG(\delta') + \frac{\lambda}{r+\gamma} F(1)(-\Delta V(\delta_0) + \Delta V(\delta)) \mathbb{1}[\delta > \delta_0]$$

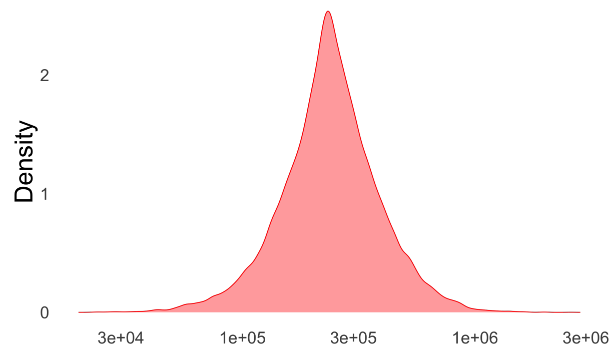
$$-\frac{\rho}{r+\gamma}\int_0^{\delta}\frac{1}{2}[\Delta V(\delta')-\Delta V(\delta)]dH(1,\delta')$$

Figure 15: Prices

(a) Prices



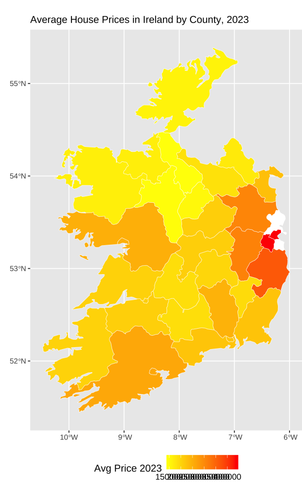
(b) Residual Prices



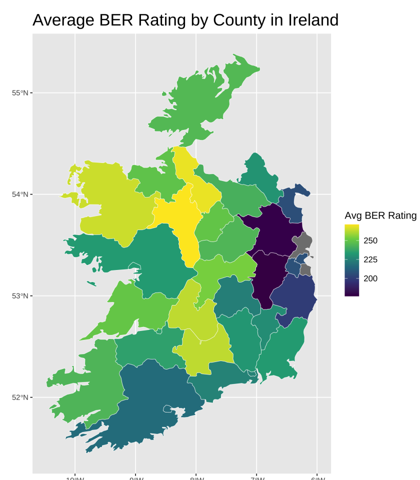
Note:

Figure 16: Prices and quality

(a) Price distribution



(b) Quality distribution



Note:

$$c_q/r=\frac{\int_0^1 V(q,\delta)dH(\delta,q)}{\int_0^1 dH(\delta,q)}$$

$$c/r=\frac{\sum_q\int_0^1 V(q,\delta)dH(\delta,q)}{\underbrace{\sum_q\int_0^1 dH(\delta,q)}_{=1}}$$

Year	Fi=0	Fi=1	Fi=2	Overall
2012.00	0.79	0.79	0.74	0.79
2013.00	0.87	0.85	0.85	0.87
2014.00	0.85	0.82	0.82	0.85
2015.00	0.83	0.87	0.82	0.84
2016.00	0.81	0.90	0.80	0.82
2017.00	0.78	0.86	0.80	0.79
2018.00	0.75	0.82	0.77	0.77
2019.00	0.72	0.83	0.74	0.73
2020.00	0.73	0.82	0.74	0.74
2021.00	0.73	0.79	0.73	0.74

Year	<730	>=730	Overall
2012.00	0.18	-0.19	0.14
2013.00	0.20	-0.15	0.14
2014.00	0.33	-0.04	0.23
2015.00	0.41	0.22	0.35
2016.00	0.37	0.36	0.33
2017.00	0.36	0.40	0.30
2018.00	0.34	0.37	0.30
2019.00	0.31	0.34	0.26
2020.00	0.26	0.27	0.21
2021.00	0.30	0.23	0.22

References

Acolin, Arthur, Jesse Bricker, Paul Calem, and Susan Wachter, "Borrowing Constraints and Homeownership," *American Economic Review*, May 2016, *106* (5), 625–629.

Allen, Jason, Robert Clark, and Jean-François Houde, "Search Frictions and Market Power in Negotiated-Price Markets," *Journal of Political Economy*, August 2019, *127* (4), 1550–1598. Publisher: The University of Chicago Press.

Anenberg, Elliot and Daniel Ringo, "The Propagation of Demand Shocks through Housing Markets," *American Economic Journal: Macroeconomics*, July 2022, *14* (3), 481–507.

Bayer, Patrick, Christopher Geissler, Kyle Mangum, and James W Roberts, "Speculators and Middlemen: The Strategy and Performance of Investors in the Housing Market," *The Review of Financial Studies*, November 2020, *33* (11), 5212–5247.

Depken, Craig A., Harris Hollans, and Steve Swidler, "An Empirical Analysis of Residential Property Flipping," *The Journal of Real Estate Finance and Economics*, October 2009, *39* (3), 248–263.

Diamond, Rebecca and William Diamond, "Affordability of Owner-Occupied Housing across US Cities," *AEA Papers and Proceedings*, May 2024, *114*, 340–345.

Duffie, Darrell, Nicolae Gârleanu, and Lasse Heje Pedersen, "Over-the-Counter Markets," *Econometrica*, 2005, *73* (6), 1815–1847. _eprint: https://onlinelibrary.wiley.com/doi/pdf/10.1111/j.1468-0262.2005.00639.x.

Gavazza, Alessandro, "An Empirical Equilibrium Model of a Decentralized Asset Market," *Econometrica*, 2016, *84* (5), 1755–1798. _eprint: https://onlinelibrary.wiley.com/doi/pdf/10.3982/ECTA10847.

Head, Allen, Huw Lloyd-Ellis, and Hongfei Sun, "Search, Liquidity, and the Dynamics of House Prices and Construction," *American Economic Review*, April 2014, *104* (4), 1172–1210.

Hugonnier, Julien, Benjamin Lester, and Pierre-Olivier Weill, "Frictional Intermediation in Over-the-Counter Markets," *The Review of Economic Studies*, May 2020, *87* (3), 1432–1469.

Kopczuk, Wojciech and David Munroe, "Mansion Tax: The Effect of Transfer Taxes on the Residential Real Estate Market," *American Economic Journal: Economic Policy*, May 2015, *7* (2), 214–257.

Krainer, John and Stephen F. LeRoy, "Equilibrium valuation of illiquid assets," *Economic Theory*, February 2002, *19* (2), 223–242.

Lagos, Ricardo and Guillaume Rocheteau, "Liquidity in Asset Markets With Search Frictions," *Econometrica*, 2009, *77* (2), 403–426. _eprint: https://onlinelibrary.wiley.com/doi/pdf/10.3982/ECTA7250.

Lee, Jin Man and Jin Wook Choi, "The Role of House Flippers in a Boom and Bust Real Estate Market," *The Journal of Economic Asymmetries*, December 2011, *8* (2), 91–109.

Piazzesi, Monika, Martin Schneider, and Johannes Stroebel, "Segmented Housing Search," *American Economic Review*, March 2020, *110* (3), 720–759.

Rekkas, Marie, Wright, and Yu Zhu, "How Well Does Search Theory Explain Housing Prices?," October 2020.

Sodini, Paolo, Stijn Van Nieuwerburgh, Roine Vestman, and Ulf von Lilienfeld-Toal, "Identifying the Benefits from Homeownership: A Swedish Experiment," *American Economic Review*, December 2023, *113* (12), 3173–3212.

Sommer, Kamila and Paul Sullivan, "Implications of US Tax Policy for House Prices, Rents, and Homeownership," *American Economic Review*, February 2018, *108* (2), 241–274.

Weill, Pierre-Olivier, "The Search Theory of Over-the-Counter Markets," *Annual Review of Economics*, August 2020, *12* (Volume 12, 2020), 747–773. Publisher: Annual Reviews.

Üslü, Semih, "Pricing and Liquidity in Decentralized Asset Markets," *Econometrica*, 2019, *87* (6), 2079–2140. _eprint: https://onlinelibrary.wiley.com/doi/pdf/10.3982/ECTA14713.

İmrohoroğlu, Ayşe, Kyle Matoba, and Şelale Tüzel, "Proposition 13: An Equilibrium Analysis," *American Economic Journal: Macroeconomics*, April 2018, *10* (2), 24–51.