Households in the Housing Market

Marx, Julie

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PhD Series 26.2020

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HANDELSHØJSKOLEN

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Julie Marx

Supervisor: Steffen Andersen

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Steffen encouraged me to spend time on numerous different project, including of course the chapters of this thesis, but also studies of farmers' fish eating habits in rural Thailand, altruism among German students, blood donor behavior in Denmark, macro effects of trust in societies, and more. Most of them did not turn into actual papers (yet), but all of them taught me invaluable lessons on research, ideas, culture, and people.

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Abstract

This dissertation addresses four aspects of household decisions in and around the housing market.

The first chapter investigates negotiations over real estate and finds that men secure better prices than women when negotiating to buy and sell property. However, the gender difference declines substantially when improving controls for the property's value; and is eliminated when controlling for unobserved heterogeneity in a sample of repeated sales. Rather than evidence of gender differences in negotiation, the initial difference in prices is evidence that men and women demand different properties. Consistently, we find no gender difference in the sales price secured for property inherited from a deceased parent. Provided appropriate controls men and women fare equally well when negotiating over real estate. The study demonstrates that inference on gender differences in negotiation relies critically on controlling for the value of the negotiated item.

The second chapter studies reference dependence among potential sellers in the housing market. It models listing decisions, and structurally estimate household preference and constraint parameters using comprehensive Danish register data. Sellers optimize expected utility from property sales, subject to down-payment constraints, and internalize the effect of their choices on final sale prices and time-on-the-market. The data exhibit variation in the listing price-gains relationship with "demand concavity" bunching in the sales distribution; and a rising listing propensity with gains. Our estimated parameters indicate reference dependence around the nominal purchase price and modest loss aversion. A new and interesting fact that the canonical model cannot match is that gains and down-payment constraints have interactive effects on listing prices.

The third chapter studies the transition to and from homeownership under the recent housing market bust using detailed micro-level data covering the entire Danish population. We document that households that are more affected by falling house prices reduced their likelihood to acquire homeownership during the bust more than other households. These households are characterized by lower levels of net worth, lower income, shorter educations, are singles, and of younger age. Combined with younger households abandoning homeownership more under the bust, the bust contributed to a significant inter-generational shift in homeownership from younger to older households.

The fourth chapter studies educational outcomes of children whose parents inherit. Family wealth and offspring achievements are highly correlated, but the causation is not clear. This study examines both the causal impact and the mechanisms of which family wealth can affect child outcomes. Using bequests from deceased grandparents, I find that the extra parental liquidity neither affects grades, high school and college enrollment, or high school drop out rates of children. Parents do not send offspring to different schools, move to better neighborhoods, or reduce their own nor their children's work time. The additional wealth is spent on household consumption through bigger houses, cars, and holiday homes. The results suggest than in a system with universal education, public funds are probably better spent on improving school quality than making transfers to parents.

Resumé (Danish abstract)

Denne afhandling behandler fire forskellige aspekter af husholdningers beslutningstagen i og omkring boligmarkedet.

Det første kapitel ser på forhandling af priser på fast ejendom og finder først, at mænd opnår bedre priser end kvinder, når de forhandler priser på køb og salg af boliger. Kønsforskellen mindskes dog væsentligt, når vi kontrollerer for værdien af boligen; og forskellen forsvinder helt, når vi kontrollerer for uobserveret heterogenitet i en delmængde bestående af ejendomme, som vi ser gentagne registrerede salg af. De først-observerede prisforskelle mellem mænd og kvinder er dermed mere et udtryk for, at kvinder og mænd efterspørger forskellige typer af boliger, end det er et udtryk for kønsforskelle i forhandlingstilbøjelighed. Det bekræftes af, at vi heller ikke finder kønsforskelle i salgspriser på boliger, som er nedarvet fra afdøde forældre. Givet tilstrækkelig kontrol for værdien af boligen, er kvinder og mænd altså lige gode til at forhandle boligpriser. Studiet demonstrerer, at det er vigtigt at kontrollere for værdien af det gode, der forhandles om, før man drager konklusioner om kønsforskelle i forhandling.

Kapitel 2 modellerer udbudsbeslutninger på boligmarkedet, nærmere bestemt *reference dependence* og *loss aversion* hos potentielle boligsælgere. Ved hjælp af dansk registerdata estimerer vi en strukturel model for husholdningers præferencer og begrænsninger på boligmarkedet. Under betingelser for udbetaling på den næste bolig optimerer potentielle sælgere den forventede nytte af at sælge en bolig og tager i processen højde for betydningen af deres valg for den opnåede salgspris og sandsynlighed for salg. Data viser 1) at forholdet mellem udbudsprisen og potentiel gevinst ved et salg varierer med graden af såkaldt *demand concavity*, 2) at der er *bunching* i fordelingen af salg, samt 3) at tilbøjeligheden til at udbyde sin bolig til salg stiger med den potentielle gevinst, man kan opnå. Vores estimater viser *reference dependence* omkring den nominelle købspris og en beskeden grad af *loss aversion* og pointerer vigtigheden af at inkludere friktioner i modeller, der beskriver økonomiske agenters underliggende præferencer.

Det tredje kapitel undersøger bevægelser ind og ud af boligmarkedet under boligprisernes fald i sidste del af 00'erne, og hvordan prisfaldet påvirkede husholdninger forskelligt. Kapitlet dokumenterer, at husholdninger, hvis økonomi var mest sårbar over for prisfald, reducerede tilgangen til boligmarkedet mere end andre husholdninger. Disse husholdninger

var karakteriseret ved mindre formue, lavere indkomst, kortere uddannelse, single-status og ung alder. Sammenholdt med det at yngre husholdninger var mere tilbøjelige til at forlade boligmarkedet i samme periode, resulterede det i, at andelen af boligejere faldt blandt yngre husholdninger og steg blandt ældre.

Der er stor sammenhæng mellem forældres formue og børns uddannelse, men om det er et udtryk for kausalitet er uklart. Det fjerde og sidste kapitel undersøger den direkte effekt af formue på børns uddannelse, samt de måder hvorpå forældre kan vælge investere i børns uddannelse. Jeg bruger arv fra afdøde bedsteforældre til at identificere stød til forældres likvide formue og finder ingen direkte effekt på hverken børns niendeklassekarakterer eller børns tilbøjelighed til at starte gymnasiet, droppe ud af gymnasiet eller starte på universitetet. Forældre bruger ikke arven på at flytte til bedre områder og skoler for dermed at sikre bedre netværk til deres børn, og de ændrer heller ikke på deres egen eller børnenes arbejdstid. I stedet bruger de arven på større huse, biler og sommerhuse. Resultaterne tyder på, at det er bedre at bruge offentlige midler på at sikre kvaliteten af uddannelsestilbud frem for at støtte forældre økonomisk.

Contents

Introduction

Housing typically is the largest household asset and decisions in the housing market significantly impacts wealth, welfare, and opportunities of households. Thus, understanding household behavior in the housing market is important. This PhD thesis analyzes different aspects of household decision making, in particular in the housing market. The four chapters of the thesis are independent research projects that can be read separately, but they are all placed within the field of Household Finance and they are all based on the use of Danish register data. In total the thesis cover the full circle of home ownership: buying, selling, and relocation, as well as the topics of negotiation, reference dependence, household heterogeneity, and education.

The first chapter is research conducted in collaboration with Steffen Andersen, Kasper Meisner Nielsen, and Lise Vesterlund. Motivated by the persistent gender gap in wages across the world, the paper studies whether men and women obtain the same outcomes when they negotiate over real estate. In the labor market gender differences in initiating and engaging in negotiations are noted as contributing to the persistent gender wage gap. Unfortunately, although negotiation in the labor market is of key concern, it is also a market where the researcher has very limited information on the 'good' that is being traded, making it challenging to examine gender differences in negotiation. We instead study gender differences in negotiated outcomes in real estate, a setting where the value of the negotiated item is clear to both the seller, the buyer, and us.

We first find that single men secure better prices than do single women when they negotiate to buy and sell property. Part of this difference results from single men and women having different characteristics and from them demanding different property characteristics, but we also (initially) find significant gender differences in negotiation. However, when we take measures to control for the value of the property, negotiation differences between genders disappear. This finding suggests that gender differences in prices are results of differences in demand rather than differences in negotiation.

To eliminate demand effect we study sales prices of "randomly" distributed properties. Using death sales where a child is selling the property of a deceased parent we imitate a natural experiment in which properties are randomly assigned to sellers, and substantially reduce (or eliminates) the demand effect. When examining sales prices of properties inherited from a deceased parent, we find that the gender difference in prices is absent, suggesting no gender difference in negotiation.

We replicate results of two American studies finding gender differences in negotiation outcomes and subsequently show that controlling for unobserved heterogeneity in properties eliminates gender differences in both cases.

Our findings suggest that initial evidence of gender differences in negotiation over real estate results from insufficient controls for the value of the negotiated item, and from failure to control for the different property characteristics demanded by single men and single women. Provided with proper controls, we find no evidence that single women fare worse than single men when negotiating over real estate.

The second chapter is a paper co-authored with Steffen Andersen, Cristian Badarinza, Lu Liu, and Tarun Ramadorai. The study exploits data on seller behavior in the Danish housing market to examine the underlying preferences of economic agents, specifically the degree of reference dependence and loss aversion.

Decisions in the housing market are in themselves interesting given the importance of housing assets in household finances. But exactly because decisions are important and because data is abundant it is also the perfect setting for studying the complex structure of preferences behind household decisions. We study the mechanism of reference-dependent loss aversion, which has been documented to result in listing prices rising sharply when sellers face nominal losses relative to the initial purchase price. In order to map the preferences behind such behavior it is important to take into account the constraints faced by the sellers, since some constraints potentially lead to behavior imitation loss aversion, without loss aversion being the reason. Important factors that may constrain the seller, but have been ignored previously, are the demand response of potential buyers, implying that listing prices and probability of sales is correlated, as well as down-payment constraints for sellers wanting to upgrade to a new home.

The paper develops an extensive model of the house selling decision for reference-dependent sellers and incorporate realistic housing market frictions such as demand effects and down-payment constraints. The model includes extensive and intensive decisions of sellers and lets the seller maximize expected utility from the realized sales price as well as gains and losses relative to the reference price, which we set to be the purchase price. Two parameters in the utility function measure the weighting of gains relative to the final price realization (reference dependence) and the asymmetric disutility of losses (loss aversion). Sellers either get utility from successful trade or they receive an outside option. They face down-payment constraint and they take the probability of sales success into account when setting the listing price.

We structurally estimate the parameters of the model using Danish register data on property transactions, mortgages and background characteristics of households, linked to data on property listings. We find that sellers show clear reference dependence and a modest degree of loss aversion around the original nominal purchase price of the house. The paper has the broader message that frictions has to be incorporated when studying underlying preferences using field data.

The third chapter is written with Marcel Fischer and Natalia Khorunzhina. Motivated by the housing market boom and bust of the 2000's, the paper studies household heterogeneity in the reactions to falling house prices.

Falling house prices constitute a risk for new home owners since it entails a risk of getting over-indebted. But some households are more affected than others. Illustrated by a simple model we predict that the propensity to become a homeowner in a market with falling prices is lower for younger households, households with low savings and income, households with low levels of education, and singles, since these households are more vulnerable to price changes.

We then test and verify these hypotheses using register data on Danish property transactions from 2004 to 2010. We find that the propensity to acquire homeownership during the bust varied significantly with household characteristics. In particular, under the bust, younger households reduced their propensity to acquire homeownership more than older households. Similarly, households with lower income, lower savings, short education, and singles reduced their propensity to become homeowners more than others. Other household characteristics vary less with the state of the housing market cycle and seem to play a less important role in explaining differences between the propensity to acquire homeownership under the bust and during other periods.

Combined with younger households abandoning homeownership more under the bust, these differences lead to a remarkable intergenerational shift in homeownership. While older households during the period had increasing homeownership rates, households under the age of 40 experienced decreasing homeownership rates.

The fourth chapter is early-stage research, diverging slightly from the other chapters in that it only addresses the housing market to a minor extent. Instead it examines the effect of parental wealth on child education and whether parents who experience a liquidity shock invests in ways that can potentially improve child education, for instance by relocating.

Education is important for opportunities later in life, but – even in a country like Denmark with universal education – education is highly correlated with family background. By studying bequests to parents, the fourth chapter seeks to determine the causal effect of wealth on child ninth grade GPA, high school enrollment, high school dropout rate, and university enrollment in a setting with free education. In line with previous studies, the paper finds no or only minor direct effects of wealth on child education.

The paper then asks why extra liquidity do not transmit into better education, by studying how parents spend a wealth shock. Parents inheriting large amounts invest in bigger homes, cars and holiday homes, but do not move to better neighborhoods, move the children to different schools, or increase family time. That is, the results indicate that a wealth shock to parents in a context of free education is not invested in child education and therefore also do not affect educational outcomes.

Thanks for reading.

Chapter 1

Gender differences in negotiation: Evidence from real estate transactions

Gender Differences in Negotiation:

Evidence from Real Estate Transactions*

Steffen Andersen
Copenhagen Business School and CEPR

Julie Marx
Copenhagen Business School

Kasper Meisner Nielsen
Copenhagen Business School

Lise Vesterlund
University of Pittsburgh and NBER

Abstract

We investigate negotiations over real estate and find that men secure better prices than women when negotiating to buy and sell property. However, the gender difference declines substantially when improving controls for the property's value; and is eliminated when controlling for unobserved heterogeneity in a sample of repeated sales. Rather than evidence of gender differences in negotiation, the initial difference in prices is evidence that men and women demand different properties. Consistently we find no gender difference in the sales price secured for property inherited from a deceased parent. Provided appropriate controls men and women fare equally well when negotiating over real estate. Our study demonstrates that inference on gender differences in negotiation relies critically on controlling for the value of the negotiated item

** Forthcoming in Economic Journal **

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1. Introduction

This study examines whether men and women secure different outcomes through negotiation for real estate. A classic example of differences in negotiation is seen in the labor market, where gender differences in initiating and engaging in negotiations are noted as contributing to the persistent gender wage gap. For example, the seminal work of Babcock and Laschever (2003) shows in a survey of new graduates that 57% of the men and only 7% of the women negotiated the initial compensation offered to them. With an average gain from negotiation of 7.4%, this differential is predicted to result in a substantial wage difference in the long run.[1] Although negotiation in the labor market is of key concern, it is unfortunately a market where it is challenging to examine gender differences in negotiation. In particular, the researcher has limited information on the value of the employee-employer match and the parties' outside options. The difficulty associated with assessing the 'value' of the negotiated 'item' thus challenges whether gender differences in outcomes necessarily result from differences in willingness and ability to negotiate.[2]

To control for the negotiated item, researchers have instead resorted to the laboratory to examine gender differences in negotiation. Building on a substantial existing literature these studies demonstrate that gender differences in negotiation is context dependent, with the gap varying with the role one holds when negotiating (e.g., Dittrich, Knabe and Leipold, 2014), the gender of the opponent (Eckel and Grossman, 2001; Solnick, 2001; Sutter et al., 2009), ambiguity (Hernandez-Arenaz and Iriberri, 2018), information (Rigdon, 2012), reputation and the potential for backlash (Amanatullah and Morris, 2010; Amanatullah and Tinsley 2013).[3]

While experimental studies are better able to control the negotiated item, it is not clear how the differences documented in these controlled settings extend to the field where negotiations involve larger stakes, are free-form, and where individuals may seek guidance from others. We examine

[1] These results have led to a push for women to lean-in and negotiate more (Sandberg, 2013). Exley, Niederle and Vesterlund (2019) however show that such a recommendation may be misguided in the presence of positive selection.
[2] Gender differences in negotiation outcomes have also been examined for items that are more easily assessed. Ayres (1991, 1995) and Ayres and Siegelman (1995) report on an audit study for car sales, finding that single women pay higher prices than do single men. Castillo et al. (2013) examine negotiations for taxi rides, finding (as in Ayres, 1991, 1995; and Ayres and Siegelman, 1995) that statistical discrimination drives gender differences in outcomes. However, audit studies instruct buyers on how to negotiate, and thus fail to capture gender differences in the ability and willingness to negotiate. List (2004) instead examines free-form negotiations over sports cards. While finding that statistical discrimination gives rise to a male advantage, the incentives of the study only resulted in transactions 3% of the time, and thus make it difficult to capture gender differences in negotiation.
[3] Further evidence on gender differences in negotiation depending on circumstances is seen in Andersen et al. (2018), Babcock et al. (2003), Bohnet (2016), Bowles (2013), Bowles and Babcock (2013), Bowles, Babcock and Lai (2007), Bowles and McGinn (2008), Bowles, Babcock and McGinn (2005), Busse, Israeli and Zettelmeyer (2017), Chandra, Gulati and Sallee (2017), Eckel, de Oliveira and Grossman (2008), Erikson and Sandberg (2012), Kray, Thompson and Galinsky (2001), Kray, Galinsky and Thompson (2002), Leibbrandt and List (2015), Small et al. (2007), and for reviews Azmat and Petrongolo (2014), Stuhlmacher and Walters (1999), and Mazei et al. (2015).

real estate negotiations to demonstrate that inference on gender difference in negotiation in the field relies critically on the ability to control for the value of the negotiated item.

Real estate accounts for about 30% of household expenditure and 50% of household savings at retirement (Poterba, Venti and Wise, 2011), and is thus a market where gender differences in negotiation can have a substantial effect on financial well-being.[4] However real estate negotiations are interesting not only because of the financial implications, but also because information on the negotiated item is abundant, and because both men and women are actively engaged as both buyers and sellers in the market. All factors that make it easier to robustly control for heterogeneity and to demonstrate that false inference may result absent such controls.

Using real estate transactions from Denmark, we examine whether men and women secure different prices, and whether these differences are robust to controls for the value of the negotiated item. First, examining negotiation outcomes of 337,685 real estate transactions of Danish properties from 1994 to 2013, we find that single men secure better prices than do single women when they negotiate to buy and sell property. Part of this difference results from single men and women having different characteristics and from them demanding different property characteristics. Second, adding to controls for individual characteristics we use the procedure of Harding, Rosenthal, and Sirmans (2003) to separate the effect of gender differences in demand from that of gender differences in negotiation. Controlling for observable property characteristics, we replicate their results and find that gender differences in negotiation contribute to the inferior prices secured by women. However, this difference is reduced when we include the tax-assessed value of the property to control for the value of the negotiated item and implicitly for characteristics that, while observable to the tax authorities, are unobservable to us as researchers. Third, we find that the effect of gender differences in negotiation on prices is eliminated when looking at repeated sales of the same property. The repeated sales analysis, which is a common approach in real estate economics, effectively controls for time-invariant heterogeneity (e.g., location amenities) in properties by including property fixed effects. The finding that proper controls for the negotiated item eliminate the negotiation effect on prices, suggests that gender differences in demand rather than negotiation is what gives rise to the initial differences in prices. Fourth, to eliminate the price differences that result from men and women demanding (and thus, selling) different properties we use a novel approach to examine differences in sales prices secured for a "random" property. We find that the gender difference in prices is absent when looking at the sales prices secured for property inherited from a deceased parent. The analysis of death sales

[4] Relatedly, Wang (2016) finds that real estate, depending on wealth, accounts for between 30% to 60% of bequests.

imitates a natural experiment in which properties are randomly assigned to sellers, and substantially reduces (or eliminates) the possibility that seller characteristics influence the item that is being sold.[5] In eliminating demand effects on the seller side, death sales provide us with an opportunity to better estimate gender differences in transaction prices that are driven by negotiation rather than by gender differences in preferences and demand for property characteristics.

Our findings suggest that initial evidence of gender differences in negotiation over real estate results from insufficient controls for the value of the negotiated item, and from failure to control for the different property characteristics demanded by single men and single women. Provided with proper controls, we find no evidence that single women fare worse than single men when negotiating over real estate.

To further demonstrate the importance of controlling for heterogeneity when drawing inference on gender differences in negotiation, we extend our analysis to evaluate the findings of a more recent US study which finds that single women secure lower unleveraged returns than single men from housing (Goldsmith-Pinkham and Shue, 2019). As with Harding, Rosenthal, and Sirmans (2003), the Danish data replicate the findings of Goldsmith-Pinkham and Shue (2019), that is, until controlling for individual and property characteristics. Once we include controls, the gender differences in real estate returns are eliminated.

In summary, we replicate the findings from two separate US studies that single women secure worse negotiation outcomes for real estate than do single men, however these differences are eliminated in the Danish data once we control for heterogeneity. As comparable controls are missing in the US data, we do not know if the gender gap in negotiation would be similarly eliminated in the US. On one hand, the Danish and US labor markets have similar characteristics in terms of female participation and unemployment, and both markets show differences that are consistent with gender differences in negotiation.[6] On the other hand, the greater degree of gender equality in Denmark may affect the results (World Economic Forum, 2017, reports that Denmark is ranked 14th on its Gender Gap Index while the United States is ranked 49th). Despite these potential differences the documented gaps in the US replicate in Denmark. While similar controls

[5] We see this as imitating a natural experiment under the assumption that the child's housing preferences are not manifested in the parent's property purchase. Consistent with this assumption, we find that 93% of inherited real estate is sold within the first year and that this is independent of gender or physical distance between the child and the parent.

[6] Comparing Denmark to the United States we find labor force participation at respectively 80.6% vs. 78.7% for men and 76.1% vs 67.9% for women, and rates of unemployment at respectively 6.9% vs. 8.7% for men and 7.4% vs 7.2% for women. Data are drawn from the OECD for 2013 (end of our time period). Although the gender wage gap is smaller in Denmark than the United States (6.3% versus 17.5%), the advancement of women to leadership positions is slow in both markets (women account for 23.6% and 21.7% of directors in Denmark and United States, respectively, and only 5.9% and 5.1% of CEOs are female in Denmark and United States, respectively).

may not eliminate the gap in negotiation in the US, we anticipate that it would reduce it, and our study demonstrates how failure to control for heterogeneity can misguide inference.

In extending the results to other large stake negotiations (e.g., salary, promotion, borrowing) one should be wary of prior evidence that gender differences in negotiation depend critically on the characteristics of the negotiation. For example, the quality of the information available, the one-time interaction, the absence of in-person negotiation and the reliance on professional counsel may well contribute to men and women securing similar outcomes in the real estate market. While the lack of gender differences in real estate negotiation may not extend to all negotiations, we do anticipate that failure to control for heterogeneity will misguide inference in all negotiations. Further, consistent with prior evidence we see our results as pointing to information and training (counsel) as mechanisms that help reduce the effect gender differences in negotiation may have on outcomes.[7]

The study is organized as follows. Section 2 presents the data and descriptive statistics. Section 3 outlines a hedonic model of property prices and explains how we estimate negotiation outcomes in the real estate market. The emphasis is on securing proper controls for the negotiated item when examining all transactions, and when examining only the properties for which we observe repeated sales. Section 4 examines gender differences when we eliminate the potential impact of gender differences in demand on the transaction price. That is, this section presents results from a restricted sample of death sales where beneficiaries sell an inherited property. Section 5 offers concluding remarks and discusses the robustness of our finding that the failure to control for heterogeneity misguides inference on gender differences in real estate transactions. An online appendix provides many supporting details.

2. Data and descriptive statistics

Our data cover all residential real-estate transactions in Denmark from 1994 to 2013. The data contain economic and personal information about buyers and sellers, as well as property characteristics and transaction prices. We derive data from six sources made available through Statistics Denmark:

1. Property transactions are from the Danish Tax and Customs Administration (*SKAT*). SKAT receives the information from The Danish Gazette (*Statstidende*). Public announcement in The

[7] See Recalde and Vesterlund (2020) for a review of policies that may reduce the impact of gender differences in negotiation. Note that while real-estate agents may render negotiation advice, the agents' fiduciary responsibility makes it unlikely that the preferences of the agent, rather than those of the client, are reflected in the negotiation.

Danish Gazette is part of the juridical registration of the transfer of ownership, which ensures that we have access to accurate and reliable information on property transactions over the sample period. The transaction data include property prices, transaction dates, as well as property identification numbers used in the housing register described below.[8]

2. Individual characteristics of houses are from the Housing Register (*Bygnings- og Boligregister, BBR*), which has detailed information on all properties in Denmark. In addition to property identification numbers and property characteristics, the data contain the personal identification numbers (*CPR nummer*) of property owners at the end of each year. We identify sellers as owners of a transacted property in the beginning of the year of the transaction, and buyers as owners of the property at the end of the year.

3. Individual and family data are from the official Danish Civil Registration System (*CPR Registeret*). These records include individual personal identification number (CPR nummer), gender, age, and marital history (marriage, divorce, and widowhood). We use these data to obtain individual characteristics as well as civil status.

4. Income data are from the official records at the Danish Tax and Customs Administration (SKAT). This dataset contains income information by CPR number for the entire Danish population. The tax authorities receive this information directly from the employers, who withhold income tax and pay it directly to SKAT, and who report the actual wages paid to their employees. The data from the tax authorities also contain an assessment of house value, which forms the basis for the property value tax and the municipality land tax. To facilitate the collection of property taxes, the Danish tax authorities (SKAT) assess the value of properties by estimating a property's value as if it were to be sold. The valuation considers factors such as local market conditions, an array of house characteristics, and permissible alternative uses of the land. The assessment is carried out every other year, and in years in which a house is not assessed by the tax authorities, the value is regulated based on the growth in local house prices. The assessment is carried out at the municipal level and incorporates factors that are unobserved in the data from the Housing Register. These factors include access to recreational space (e.g., beach, forest, or lake), distance to public transportation, and other amenities (e.g., schools). We interchangeably refer to the tax authorities' property assessment as tax-assessed value or assessed value.

[8] Our transaction data do not contain information about whether realtors represent the buyer and sellers. In Denmark sales in are typically handled through a realtor while purchases are more commonly done without representation. However, our initial analysis fully replicates results from the United States where it is more common to have representation on both sides of the market.

5. Educational records are from the Danish Ministry of Education. All completed (formal and informal) education levels are registered on a yearly basis.

6. Employment status records are from Statistics Denmark's IDA database. An individual's employment status is classified at the end of November each year. Individuals are classified as employed when the majority of their personal income derives from paid employment, and as self-employed when the majority of their personal income is from self-employment. Individuals outside the labor market are classified as "retired" if the majority of their income is from private or public pensions. Finally, individuals are classified as unemployed if they are neither employed nor self-employed and have not retired.

Collectively, these data sources allow us to assess transaction data, and link them to buyer and seller characteristics. To correctly identify the agents involved in the transaction, we exclude properties that are traded more than once within a year. To analyze the effect of gender on real estate negotiations, we focus on transactions involving single females and single males and require that each household has an unchanging number of adult members (between 18 and 65 years of age) over a two-year period around the time of the property transaction. This focus ensures that the individuals engaged in a transaction do not change status from being single to being part of a couple, or vice versa. We further restrict the sample to arm's length transactions by excluding transactions between family members. Finally, we focus our analysis on transactions of houses and apartments and exclude, on account of poor controls and small samples, cottages, farms, and cooperative housing. Our gross dataset includes 337,685 observations of real estate transactions in Denmark from 1994 to 2013. Table 1 presents descriptive statistics on buyer and seller characteristics, while Appendix A provides additional details on the sample selection and definition of variables.

[Table 1 here]

Table 1 shows buyer and seller characteristics for all transactions, and for transactions involving single women or single men among buyers and sellers, respectively.[9] Around 65,000 (71,000) transactions, corresponding to 19% (21%) of all transactions, have a buyer (seller) who is single.

[9] As we do not know how couples make decisions, we follow the approach of the literature and study the decisions of singles when examining gender differences. With singles accounting for 35% of the adult population we see it as important to document differences within this population. Although most singles in our sample were previously in a co-habiting couple (64% within the last eight years), there are nonetheless observable differences between singles and couples. While we control for such differences it may be asked if gender differences among singles extend to individuals in couples. We address this concern in Section 5 by examining a younger segment of our sample (40 and younger) and find that our results are fully replicable in a sample where observable characteristics between singles and couples are similar.

Among buyers, single women are older, have lower income, have greater wealth, and are better educated, than single men.[10] The same contrast holds among sellers, where these differences are slightly larger. The difference in individual characteristics of single males and single females highlights the importance of controlling for individual characteristics when assessing the effect of gender on realized real estate prices. Table 2 shows property characteristics for all transactions, and transactions involving single women or single men among buyers and sellers, respectively.

[Table 2 here]

A simple comparison of transaction prices, as shown in Table 2, reveals that single women both buy and sell at higher prices than do single men. Panel A focuses on houses and shows that single women buy houses that cost DKK 175,600 (EUR 23,600) more than those bought by single men. The difference in transaction prices implies that single women buy houses that are 17% more expensive than those bought by single men. When single women sell, the transaction price is DKK 128,500 (EUR 17,200) higher than houses sold by single men. The difference in transaction prices corresponds to a 10% gender difference in sales prices. While the finding that women buy and sell at higher prices than men may merely reflect that women purchase more expensive houses, the evidence that the gender gap is smaller when selling than buying may indicate that single women are worse at negotiating: they pay more when buying a property, and while also selling at a higher price, they are not as effective in recapturing the higher purchase price. Absent controls for individual and property characteristics the raw data suggest that, when negotiating over real estate, single women leave DKK 47,100 (EUR 6,300) more on the table than do single men. However, this difference in raw transaction prices may result from single women and single men demanding different property characteristics, either because of differences in financial constraints and other individual characteristics (Table 1), or because their preferences for property characteristics differ.

Potential differences in demand imply that we must control for characteristics of transacted properties to uncover differences in negotiation separate from differences in demand. A closer look at Panel A of Table 2 reveals, however, that gender differences in transaction prices do not correspond to substantial differences in researcher observable house characteristics. Gender differences are small in easily observable property characteristics that are likely to increase the transaction price and are small relative to the 17% and 10% gender difference in purchase and sales prices, respectively. When purchasing property, the gender difference in interior size is less than 2 square meters (2%), equivalent to 0.04 more rooms (1%), and less than 0.03 more bathrooms (3%). When selling a property, gender differences are slightly larger. The relatively

[10] Amounts in our study are in 2015 Danish kroner (DKK). One Euro equals 7.45 Danish kroner.

larger gender differences in property characteristics when selling compared to purchasing, but relatively smaller gender differences in transaction prices when selling compared to purchasing suggests that the gender difference in prices are unlikely to be fully accounted for by observable property characteristics in the Housing Register.

The Housing Register does not capture all characteristics of a transacted property. In particular, the Danish tax authorities have more detailed information available when assessing the value of a property (e.g., local market amenities and conditions, permissible alternative uses of the land). By including the tax authorities' property assessments, we may better control for the value of property characteristics that are not captured in the raw characteristics given in the Housing Register. Using the tax-assessed value of the property in the year prior to the transaction, we find that properties in transactions involving single women have systematically higher assessed value than properties in transactions involving single men. When purchasing a property, the difference of DKK 112,200 (EUR 15,000) in the assessed value corresponds to almost two-thirds of the observed gender difference in transaction prices. When selling, the difference of DKK 96,900 (EUR 13,000) in assessed value corresponds to three-quarters of the gender difference in transaction prices. While using the tax authorities' assessed property value as the benchmark reduces the gender difference in transaction prices substantially, an economically large difference in transactions prices remains. Single women buy properties priced DKK 63,400 (EUR 8,500) above the assessed value relative to single men, but only sell properties at prices DKK 31,600 (EUR 4,200) above the assessed value relative to single men. The triple difference of DKK 31,800 (EUR 4,300) suggests that single women leave 2% to 3% of the property's value on the table when they negotiate over real estate.

Panel B focuses on apartments and provides additional insights into the potential gender differences in negotiations. The market for apartments is more liquid and transparent than the market for houses, making it easier for market participants, as well as researchers, to estimate the property's value by finding the price from a recent transaction involving a comparable apartment.[11]

In this more liquid and transparent, and thus less ambiguous, market we continue to find gender differences in prices.[12] Panel B shows that single women buy apartments at prices that are DKK 120,700 (EUR 16,200) higher and sell apartments at prices that are DKK 99,700 (EUR 13,400) higher than single men. The difference in transaction prices of DKK 21,000 (EUR 2,800)

[11] Apartments are transacted more frequently which increases both liquidity and transparency, with the latter resulting from it being easier to find a comparable transaction. In our data the average number of transactions is 1.1 per house and 1.26 per apartment. Further, average transactions in apartment blocks (more than 8 units) equal 3.9.
[12] Past research finds evidence that women fare worse in negotiations that involve more ambiguity (see, e.g., Bowles and McGinn, 2008; Leibbrandt and List, 2015).

remains consistent with single women performing worse in real estate negotiations. Again we notice that observed property characteristics seem small relative to the difference in price. Relative to men, women buy and sell slightly larger apartments. Similarly, using the tax-assessed value, we note that part of the difference likely results from unobservable differences in the properties demanded by single men and women. Single women buy apartments priced DKK 36,900 (EUR 5,000) above the assessed value of those bought by single men, but only sell properties at prices DKK 20,100 (EUR 2,700) above the assessed value of those sold by single men. The triple difference suggests that single women leave 1% to 2% of the apartment's value on the table, relative to single men.

The main takeaway from Table 2 is thus that gender differences exist in transaction prices. Single women buy at higher prices than those at which they sell, relative to single men. Although part of the gender difference in prices appears to be explained by gender differences in demand for observable and (to us) unobservable property characteristics, differences in transaction prices may also result from gender differences in negotiation.[13] The identification of potential gender differences in negotiation, whether as a result of differences in bargaining power, ability, or frequency of initiating a negotiation, thus warrants a more careful analysis of our sample of real estate transactions.

3. Real estate negotiation

For heterogeneous goods like real estate, the market is thin, and no observed market-clearing price exists. Facilitating negotiation, real estate transactions arise when a buyer's willingness to pay is higher than the seller's reservation price. Thus the observed transaction price will not only depend on the characteristics of the transacted property, but also on the negotiation between buyers and sellers.

One approach to uncovering gender differences in negotiation outcomes is to examine a simple hedonic model of prices on property characteristics. The hedonic model compares the effect of

[13] Gender differences in both purchase and sales prices may reflect differences in demand and negotiation. For example, suppose there are no gender differences in negotiation and that women buy houses with a nicer view. If we fail to control for the nicer view then we will see women pay more when they buy and get more when they sell, and these gender difference in prices will only reflect that women demand different houses than those demanded by men. Gender differences in negotiation would arise as gender differences varying between the purchase and sales side, and such differences would appear even if it varied by the individual's role and only appeared on the purchase or sales side (for evidence of role influencing outcomes see e.g., Dittrich et al., 2014; Andersen et al., 2018).

gender on real estate prices based on the characteristics of buyers and sellers. Table 3 presents results.

[Table 3 here]

We note first that individual characteristics such as income, education or being self-employed are predictive of a higher property price for both buyers and sellers. Further, as expected from the raw means, the simple hedonic approach reveals that single women fare worse than men when negotiating over property. Women leave more money on the table than men when negotiating over houses or apartments.[14] Controlling first for observable property characteristics, Column 1 of Table 3 reveals that single women buy houses at prices that are 11.0% greater and sell houses at prices that are 7.0% greater than those of single men. This difference implies a gender difference in negotiation: single women secure prices that are 4% worse than single men.

Column 2 of Table 3 shows that the gender difference is small for apartments. Single females pay 7.5% more when they buy apartments, but also receive 7.1% higher prices when they sell, relative to single men. As noted above the market for apartments is more liquid and transparent and less ambiguous. Prior research thus suggests that the estimated coefficient on negotiation is expected to be smaller for apartments. Column 3 confirms these findings when we jointly analyze houses and apartments.

An important caveat, as shown by Harding, Rosenthal, and Sirmans (2003) (henceforth HRS), is that the simple hedonic model fails to control for differences in demand for unobserved property characteristics. That is, the estimated gender effect includes both differences in negotiation and in demand. To examine whether gender differences in the realized transaction prices result from differences in negotiation or from men and women demanding different types of properties, we therefore follow the approach of HRS and assume trading symmetry in both negotiation ability and demand. The assumption implies that the negotiation ability is symmetric and independent of whether the individual is a buyer or a seller.[15] This symmetry assumption helps separate negotiation effects from demand effects by adding differences in seller-buyer characteristics and sums of seller-buyer characteristics to a standard hedonic model of house prices. The main HRS model for estimating gender differences in negotiation is specified in Equation (1), where the dependent variable is the log price, y_{ijt}, of house (or apartment) i in quarter j in year t:

[14] Appendix Table E1 expands the hedonic model with improved controls and shows how the gender difference is reduced and ultimately eliminated when controlling for the value of the negotiated property.
[15] See Appendix B for a description of the HRS model.

$$y_{ijt} = \alpha_j + \alpha_t + \beta X_{it} + \delta\left(D_i^{sell} - D_i^{buy}\right) + \gamma\left(D_i^{sell} + D_i^{buy}\right) + \varepsilon_{ijt}\,. \quad (1)$$

Where X_{it} is a vector of observed property characteristics for property i at time t, and D_i^{sell} and D_i^{buy} are vectors of seller and buyer characteristics. The coefficient γ on the sums of the seller-buyer characteristics is the estimated demand effect, whereas the coefficient δ on the differences in seller-buyer characteristics is the estimated negotiation effect. To control for seasonality and general market trends in house prices, we further include quarter and year fixed effects (α_j and α_t, respectively).

[Table 4 here]

We begin by using the HRS specification, with controls corresponding to Table 3 above. The associated results are shown in Table 4, first separately for houses and apartments, and then when pooling the two.[16] For each of the three models, in the first column we show the estimated negotiation effects, δ; in the second column, the estimated demand effects, γ; and in the third column, other controls, including the effect for variables that only refer to buyers (out-of-town and first-time home buyers), where the demand and negotiation effects cannot be separated. Note that a positive negotiation coefficient reflects greater bargaining power, in the sense that the seller sells for more and the buyer pays less, and that a positive demand effect implies greater willingness to pay.

We see in Columns 2 and 5 of Table 4 that for both houses and apartments the demand effect of income, education and being self-employed tends to increase property prices; however, as seen in Columns 1 and 4, such characteristics are also correlated with securing worse outcomes when negotiating over real estate. These results replicate those of HRS, who argue that the inverse relationship between negotiation and income may reflect the effect of diminishing marginal utility of income.[17] In explaining the gender differences in prices in Table 2 and 3, we see from the indicator on single female in Table 4 the role played by differences in negotiation and in demand. First, Columns 2 and 5 (for houses and apartments, respectively) of Table 4 reveal that single women demand more expensive properties than those demanded by single men. Second, if the observed variation in transaction prices results from women being disadvantaged when bargaining

[16] See Appendix Table D4 for the distribution of trades between single females, single males, and couples. For brevity, we do not report the estimated coefficients on property characteristics throughout the analysis. Tables with estimated coefficients on property characteristics are available from the authors upon on request.

[17] Augmenting the HRS model to include wealth does not alter the coefficient on gender statistically or economically; see Appendix Table C1. We, also note that including wealth does not change the coefficients on, e.g., education or income as these variables capture the relative effect of differences in individual characteristics of buyers and sellers. If individuals have declining marginal utility of wealth, we expect individuals with lower income to negotiate harder (even after controlling for wealth). For comparability, we maintain the HRS specification.

we expect a negative negotiation effect. Consistently, Column 1 in Table 4 shows that relative to single men, single women leave 2.0% on the table when trading houses.[18] Column 4 in Table 4, in contrast, shows that women only leave 0.2% on the table when trading apartments. In Columns 7, 8, and 9, we confirm these results when combining houses and apartments into one specification and when including an interaction term between single female and an indicator for apartments. We find a gender difference in negotiation corresponding of -2.1% on prices for houses, and a gender difference of -0.7% for apartments. That is, we replicate earlier evidence that single women fare worse than single men when negotiating over real estate.[19]

We noted in Table 2 that a large fraction of the gender difference in property prices may be driven by unobserved heterogeneity in the transacted property. To further our understanding of potential gender differences in negotiation, we next aim to better control for unobserved heterogeneity. Specifically, we control for the tax authorities' property value assessments in the year prior to the transaction. Table 5 includes the log of the tax-assessed value of the property. Looking at the specification for houses, we see in Column 3 that a 10% increase in the assessed value of the property is associated with a 9.2% higher transaction price, after controlling for time-trends and observable property characteristics. Thus, heterogeneity in tax-assessed values are similarly valued when the properties are transacted. This finding indicates that the tax-assessed value helps control for the negotiated item, and that it in turn helps us identify gender differences in negotiation.

We see for houses in Column 1 of Table 5 that half of the estimated gender difference in negotiation disappears when we control for the tax- authorities' assessed value of house characteristics that are observable to them.[20] Comparing the results for the pooled sample in Column 7 of Tables 4 and 5, we see that the estimated gender difference in negotiation decreases from -2.1% for houses to -1.0% when we control for the assessed value. For apartments, the

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[18] The effect does not depend on the state of the market. Running a regression with year-gender interactions shows a persistent difference over 20 years, a period that includes both the housing market bubble and bust.

[19] Our result for houses corresponds to those of HRS, who find a gender difference of 3.6% for American house transactions, when controlling for MSA size. While using more precise controls (municipality size and single/couple status) we replicate the HRS findings of negative effects on negotiation of income, being a couple, college educated, self-employed, and a first-time buyer. The only discrepancy is for age, where HRS find a negative effect (-0.0017) and we find a positive effect (0.001); note however that our estimated coefficient on age is reduced to zero when controlling for assessed property value or for property fixed effects in our repeated sales sample.

[20] To examine whether the unobserved property characteristics are correlated with ownership length due to, for example, gender differences in the ability or interest in maintaining the property, we also control for the length of the seller's ownership as well as the interaction between length of ownership and gender (Appendix Table F1). Although transaction prices, as expected, decline with ownership, we find no evidence of gender differences being driven by ownership length.

estimated gender difference in Column 7 is reduced from -0.7% to -0.3%.[21] This reduction in the coefficient on gender demonstrates that our initial evidence of gender differences in negotiation partially results from insufficient control of the negotiated item.

[Table 5 here]

Results from Tables 4 and 5 highlight that a main caveat to estimating gender differences in negotiation is whether we have properly controlled for property characteristics and thus for potential gender differences in demand. While the hedonic model includes many observable property characteristics, one might be concerned about whether unobserved property characteristics (e.g., location amenities or property quality) correlate with potential gender differences in demand. The HRS model improves on the hedonic model by using buyer-seller sums to control for demand effects. If men and women not only value a particular characteristic differently, but also purchase different property characteristics, then we expect demand coefficients to change once we include unobserved property characteristics as controls. The inclusion of unobserved property characteristics will also change coefficients on bargaining effects because they are estimated relative to the value of the negotiated item. Comparing the estimated coefficients in Table 4 to those in Table 5, we note that the estimated coefficients on the demand effects and on the bargaining effects generally decline, Columns 2 and 1, respectively. Including the assessed value reduces the unobserved heterogeneity in house prices, and highlights that the initial finding of gender difference in negotiation can be attributed to an inability to control for unobserved heterogeneity through the inclusion of buyer and seller characteristics.

A common approach for capturing unobservable property characteristics is to conduct a repeated sales analysis that includes property fixed effects to control for time-invariant heterogeneity (e.g., location amenities or property quality) in properties. When the specification includes property fixed effects, gender differences are estimated using variation in transaction prices of the same property across time, which ensures that the estimated gender difference is not driven by preferences for specific locations or other unobserved time-invariant house characteristics. The remaining sample consists of 97,216 property transactions of houses and apartments that have been traded more than once between 1994 and 2013. We find that the repeated sales sample have characteristics that mirror those of all transactions, and that we replicate

[21] Results are similar when controlling for wealth in Appendix Table C2. The reduction in the gender gap in prices is similar for the hedonic model in Appendix E1 where the assessed value decreases the gender gap in prices for houses from -4% to -1.9% and for apartments from -0.4% to -0.2%.

the results of Table 5.[22] Strikingly, while the gender difference in negotiation remains in the sample of repeated sales, we see in Table 6 that this is not the case when we include property fixed effects to control for time-invariant heterogeneity in properties.

[Table 6 here]

The results in Table 6 reveals that the gender differences in negotiation completely disappears, while a substantial demand effect remains.[23] Thus, no differences exist in the estimated negotiation effect of single men and of single women in the Danish real estate market when we properly control for differences in location amenities and property quality. We find no gender difference for either apartments or houses, suggesting that the estimated gender differences in negotiation in Table 2 to 5 are artefacts of the econometric specification, as opposed to men and women securing different negotiation outcomes. We also note that the coefficient on the single female indicator is quite precisely estimated to be (close to) 0.[24] The coefficients on the single female indicator do not become statistically insignificant because of large standard errors. Standard errors in Table 6 are of the same order of magnitude as in the baseline results in Table 4.

Figure 1 summarizes the findings of Tables 4 to 6 by plotting the estimated gender difference in negotiations as well as the 95% confidence interval. The figure indicates that the estimated gender differences diminish when we include the assessed house value as a control, and they disappear when we include property fixed effects to control for unobserved heterogeneity in house quality. A potential concern when examining repeatedly transacted properties is that negotiations over such properties are less ambiguous and that the absence of a gender difference could result from the decrease in ambiguity rather than from improved control of unobservable property characteristics. To address this concern, we first note that the gender difference in negotiation remains in the sample of repeated sales, and that it is eliminated only when we include property fixed effects.[25] Second, when examining the subsamples of repeated sales with two versus three or more transactions, we find that the gender effect is the same in the two subsamples, and that it is

[22] See Appendix Table D1 and D2 for the repeated sales equivalents of Table 1 and 2. See also Appendix Table F2 for Table 6 without property fixed effects.

[23] Controlling for wealth provides similar results; see Table C3.

[24] As seen in Appendix Table E1, the results are similar in a simple hedonic model that does not control for differences in demand. For example, when accounting for differences in demand, we found that property assessment controls decrease the gender gap for houses from 2.1% to 1.0%, and that the gap is further reduced to 0.0% when looking at repeated sales. Absent controls for differences in demand, the hedonic model on the pooled housing and apartment data shows that property assessment decreases the gender gap from 4.1% to 2.0% and that restriction to repeated sales further decreases it to an insignificant 0.0%.

[25] The gender gap in the sample of repeated sales is slightly smaller than in the general sample (-0.8% versus -1.0%). See results in Appendix Table F2.

eliminated in each sample only when including fixed effects.[26] While we find no evidence to support the argument that a reduction in ambiguity explains our inference from the repeated sales sample, we nonetheless leverage another method of controlling for demand to further validate the finding that gender differences in negotiation does not affect outcomes in real estate negotiations.[27] In particular we next use a more direct approach to secure that differences in demand do not influence the results. We perform an out-of-sample test of gender differences in transaction prices where individuals are selling a close-to-random property. This imitation of a natural experiment exclusively looks at death sales in which inherited properties are sold by an only child of a deceased parent.

4. Death sales

In the previous section, we find no gender differences in negotiation when we control for time-invariant, but unobserved, characteristics of houses and apartments. To further examine gender differences in negotiation in the real estate market, we next employ a novel research design that imitates a natural experiment in which properties are randomly assigned to sellers. We thereby eliminate potential differences in demand on the sales side. Death sales thus help us estimate gender differences in the realized transaction prices that are more likely to be driven by negotiation.

To identify property owners who have died, we use information from the Danish Cause-of-Death Register at the Danish National Board of Health (*Sundhedsstyrelsen*). The source of these data is the official death certificates issued by a doctor immediately after a death. Danish law further obliges the relatives to report the death to their local funeral authority within two days. The funeral authority formally notifies relevant government agencies, including the Central Office for Personal Registration (*CPR Registeret*) and the probate court (*Skifteretten*), which supervises the process that transfers legal title of property from the decedent's estate to her beneficiaries. The probate court posts a notice in The Danish Gazette (*Statstidende*) to advertise for creditors, who in turn have 8 weeks to report their claims on the estate. Following the notice period, assets are either liquidated or valued by the probate court with the purposes of establishing the net worth of the estate,

[26] See Appendix Table F3 and F4 for the analysis on the two subsamples of properties that were transacted two versus three or more times.

[27] A hedonic model with buyer and seller fixed effects similarly controls for demand, reveals that the purchase price is 4.0% higher for a single woman than it is for a single man, and that the sales price is 3.6% higher for a single woman than a single man. Absent fixed effects the coefficients are 6.9% and 6.0% respectively (the comparable gap for the entire sample is -1.0%). Thus the gender gap in prices decreases from -0.9% to -0.4% after controlling for individual specific demand. A table with estimated coefficients on the hedonic model with buyer and seller fixed effects is available from the authors upon on request.

meeting liabilities, and incurring the estate tax. At the closing of the estate, the residual is paid out to the beneficiaries. According to the Association of Danish Estate Lawyers, estates take, on average, nine months to resolve. During this period, beneficiaries are entitled to appoint a real estate agent to secure the sale of the property.

We restrict the sample to properties sold by the beneficiary of a deceased owner. More specifically, we identify 13,953 houses and apartments in our sample, for which the owner is single or widowed, has only one child, and dies. The sample is obtained by linking owners to their beneficiaries using the data from the Civil Registration System, which allows us to link parents and children using personal identification numbers (CPR nummer). To ensure that the beneficiary has decision power over the estate and, therefore, approves the sale of the inherited property, we focus on inheritance cases with a single beneficiary. This focus simplifies the analysis, as the beneficiary is either single male, single female, or a married couple.[28]

The advantage of analyzing death sales is that the gender of the beneficiary is likely to be determined by nature.[29] Table 7 shows property characteristics for all death sales, and for beneficiaries who are single men or single women.

[Table 7 here]

Table 7 shows that the characteristics of inherited houses are close to the characteristics of all houses in our sample. The main difference arises from the fact that death sales consist of properties owned by households comprised of a single and older member. Such properties are typically smaller and older than the average property. We also note that small differences exist in the property characteristics for single male and single female beneficiaries. Single women beneficiaries tend to sell their inherited properties at higher prices than do single male beneficiaries, although property characteristics, as summarized by the tax authorities' assessed value of the property, explain a large part of this difference. If anything, the descriptive statistics do not support gender differences in negotiation in favor of men.

In looking at death sales we are controlling for differences in demand by design, thus we can use a simple hedonic model to estimate gender differences in negotiation. In Column 1 of Table 8

[28] As in the main analysis, we only include to arm's-length transactions, by excluding transactions between family members. Similar to Andersen and Nielsen (2017) we find that around 93% of all inherited houses end up being sold at arm's length. More importantly, we find no difference in the propensity to sell the house at arm's length between single female beneficiaries and single male beneficiaries. Thus, the potential bias resulting from transfers of ownership within the family is likely to be small.

[29] Over 95% of beneficiaries in our death sample are born prior to 1980, before current techniques to identify the gender of children were widespread. Moreover, no evidence exists, that we are aware of, for a "missing women" problem (Sen, 1992) in Denmark.

we find no significant difference in the sales prices of houses secured by single male and single female sellers. By contrast on the purchase side, that is from the perspective of the deceased parent, we continue to find that single women buy at prices that are greater than that of single men. Note however that in the simple hedonic model, the estimated coefficient of 3.6% for single women buyers captures both gender differences in negotiation and in demand. Column 2 shows the results for apartments and confirms no gender difference in selling prices. The limited number of inherited apartments however makes it difficult to draw inference from Column 2. Indeed the small sample may help explain why we do not see a gender effect on buying apartments (with only 331 purchases made by single women)[30]

[Table 8 here]

While our sample of death sales controls for differences in demand and allows us to assess differences in negotiation directly in the hedonic model, it may be of interest to confirm that similar results are secured when using an HRS specification. The challenge in doing so lies with the deceased parent purchasing the property and the beneficiary child selling it. Thus, in extending Equation (1) it may be argued that deceased parent characteristics influence demand and beneficiary child characteristics influence negotiation. The negotiation results are however the same whether we only include the beneficiary seller characteristics, or use the deceased-owner characteristics when determining demand (i.e., using 'deceased-owner'-buyer sums) and beneficiary-seller's characteristics when determining negotiation (i.e., using 'beneficiary-seller'-buyer differences).[31] We find in both cases that the estimated coefficient of the negotiation effect for single females is small and statistically insignificant.[32]

Results from the death sale analysis bolster our finding that gender differences in negotiation in the real estate market disappear once we control for unobserved heterogeneity in housing quality. Women and men realize the same value when they sell property they inherit from their

[30] Other controls, that are otherwise significant, such as couple seller and seller education, are also statistically insignificant in Column 2 of Table 8.
[31] The latter uses "deceased-owner" characteristics because the deceased person's characteristics led to the purchase of the property (i.e., the deceased's willingness to pay and the deceased preferences for the property). The bargaining effect, on the other hand, is given by the beneficiaries, since they are in charge of selling the property. That is the coefficient on 'deceased-owner'-buyer sums, γ, controls for the demand effect, which is related to the choices of the deceased owner. The coefficient on the 'beneficiary-seller'-buyer differences is the negotiation effect, δ, and relates to the seller beneficiary, who is in charge of the negotiation.
[32] Appendix Table F5 reports on the specification with 'deceased-owner'-buyer sums 'beneficiary-seller'-buyer difference, with the negotiation effect on single female for housing being an insignificant -0.2%. The specification does not lack power despite the small sample size. Almost all of the seller characteristics (e.g., couple indicator, age, income, and education) are both statistically and economically significant. Gender, on the other hand, is statistically and economically insignificant. Further as seen in Appendix Table C4 the results are robust to controlling for wealth.

deceased parents. Eliminating the possibility that seller characteristics are related to property characteristics, we find no gender difference in realized property prices.

5. Concluding remarks

Our study contributes to the literature examining whether men and women secure different outcomes through negotiation. We study large stake negotiations using data from the residential real-estate market, where we are able to secure proper controls for value of the item. Our preliminary analysis uncovers a gender difference in negotiation that disappears when we adequately control for heterogeneity in housing. At first glance, females appear to realize worse prices when they buy or sell property. However, women demand property characteristics with higher value assessments, and this helps explain the difference in transacted prices: higher purchase and sales prices for single women than for single men. Our initial finding that females leave 2.1% on the table when they negotiate declines to 1.0% when we use the tax authorities' assessments of property values to control for unobserved heterogeneity. When we further focus on the subset of properties with repeated sales in our data, for which we can control for time-invariant heterogeneity in quality (e.g., location) by including property fixed effects, the gender difference disappears. Finally, we use a novel procedure to control for differences in demand. In particular we confirm our findings by examining beneficiary sales of inherited properties seeing these as sales approximating randomly assigned properties. We find that single male and single female beneficiaries realize the same sales prices when they are selling inherited properties. This analysis rules out the possibility that the estimated gender difference is confounded by differences in demand for housing. We conclude that men and women secure the same outcomes when negotiating over real estate. Our results demonstrate how failure to properly control for the negotiated item may lead to misguided inference on gender differences in negotiation.

The key implication of our findings is that studies of gender differences in negotiation must control for both individual characteristics that drive demand and for the characteristics of the negotiated item. To underscore the importance of this finding we extend our analysis to a recent study of gender differences in return from real-estate negotiations in the US. Using the CoreLogic data on real-estate transactions Goldsmith-Pinkham and Shue (2019) find that the return secured by women is 1 to 2 percentage point lower than that secured by men. We replicate their finding when applying their analysis to our data. Women in Denmark earn a 1.7 percentage point lower return per year compared to men.[33] In contrast to the data used in Goldsmith-Pinkham and Shue (2019), our data contains information on individual characteristics (e.g., age, income, and education) as well as property characteristics. These differences are expected to influence the estimated gender differences in returns. Controlling for individual characteristics we see a 75% reduction in estimated gender gap, a gap that is fully eliminated when we further control for house characteristics and the tax-assessed value of the property. In fact, we find a precisely estimated gender difference of 0% in the return to real estate when the specification includes controls for individual and house characteristics.[34] In extending our examination to that of Goldsmith-Pinkham and Shue (2019), we replicate the gender differences in unleveraged returns documented in the US data, but also find that these differences are eliminated when including controls that are not available in the US data. Thus, using two different analyses our study points to the importance in controlling for heterogeneity and shows that single men and single women secure the same outcomes in the Danish real estate market.

As we do not know how couples make decisions, our analysis explores gender differences by examining outcomes for singles. With singles accounting for 35% of the adult population and for 20% of the transactions in our sample, it is important to document that in contrast to initial evidence single women are not disadvantaged when negotiating for real estate. Nonetheless it may be questioned whether potential differences result from selection in to (or out of) being a couple, or from being in a couple. Although the vast majority of singles previously were in a couple, both observable and unobservable characteristics may vary between singles and individuals in couples.[35] Indeed single females in our sample are less likely to have school-age children, are older and have greater wealth than females in couples.[36] Although we control for individual characteristics throughout our analysis, we examine if our results hold in a younger population where singles are more similar to individuals in couples. Looking at the sample of those age 40 and younger, where the differences in observable characteristics are smaller between singles and individuals in couples, our results replicate, by documenting a substantial gender gap among singles which is eliminated

[33] For comparison Goldsmith-Pinkham and Shue (2019) find absent controls that single women secure a return which is 1.6% lower than that of single men. After including Zip-Year-Month fixed effects the estimate drops to 1.3%, and further drops to 1.1% when controlling for holding length. As shown in Columns 1 to 3 in Appendix Table F6 the corresponding estimates in our data are 1.7%, 1.2% and 0.8%, respectively.

[34] See Appendix Table F6 Column 4 through 6. To mirror our earlier results we do not control for wealth, however the results are identical when also controlling for wealth.

[35] Of the population of singles 35% were in a couple within the last three years and 64% within the last eight years; for those 40 and younger the rates are 38% and 71%, respectively. Further, the likelihood of having been in a couple is comparable for men and women.

[36] See Appendix Table D5.

when controlling for heterogeneity.[37] Thus we find similar results when looking at a sample where differences between singles and individuals in couples are small.

As noted previously it may be questioned how our results on real estate negotiations in Denmark extend to the US or to negotiations in general. Using the same procedures and similar controls to those of two US studies we replicate the finding that real estate negotiations put women at a disadvantage. While this gender difference is eliminated when using the superior controls offered in the Danish data, we do not know if similar controls would eliminate the gender gap documented in the US data. However we see it as unlikely that the inference drawn absent such controls is not similarly misguided. The lesson should be the same when extending the results to other forms of negotiations. With previous research showing that gender differences in negotiation outcomes depend critically on the characteristics of the bargaining environment, we recognize that gender differences in negotiations are likely to have a larger impact in negotiations that are in-person and where the outcome is more ambiguous, dependent on confidence, and where there is greater potential for back lash (e.g., salary and promotions see Recalde and Vesterlund, 2020, for review). While the absence of a gender gap in real estate negotiations is unlikely to extend to all negotiations, our study suggests that failure to control for heterogeneity is likely to lead to biased estimates of gender difference independent of the negotiation characteristics.[38] Furthermore in thinking about initiatives that may reduce the impact of gender differences in negotiations we see it as informative for future policy that men and women secure the same outcomes when negotiating in a market where they can secure guidance and information on negotiated outcomes from a third party. While we are unable to determine whether the absence of a gender gap results from there being a realtor and information being accessible, we see the results from the real estate market as suggestive of the institutional changes that may help men and women secure the same outcomes when negotiating in other markets.

[37] See Appendix Table D6, as well as Table F7 through F9. The effect on single female decreases from -1.7% to -1.2% when controlling for property assessment, and to -0.4% in the sample of repeated sales with property fixed effects (compared to -2.1%, -1.0%, and 0.0% for the entire sample).

[38] For example, Bowles, Babcock, and McGinn (2005) highlight how the gender gap in negotiation depends on the constraints and triggers of the particular negotiation. As noted in the introduction gender differences in negotiation may depend on the role one holds when negotiating, the gender of the opponent, ambiguity, information, and the potential for backlash.

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Figure 1: Summary of results

This figure plots the point estimates and 95-percent confidence intervals of female negotiation across Table 4 to Table 6.

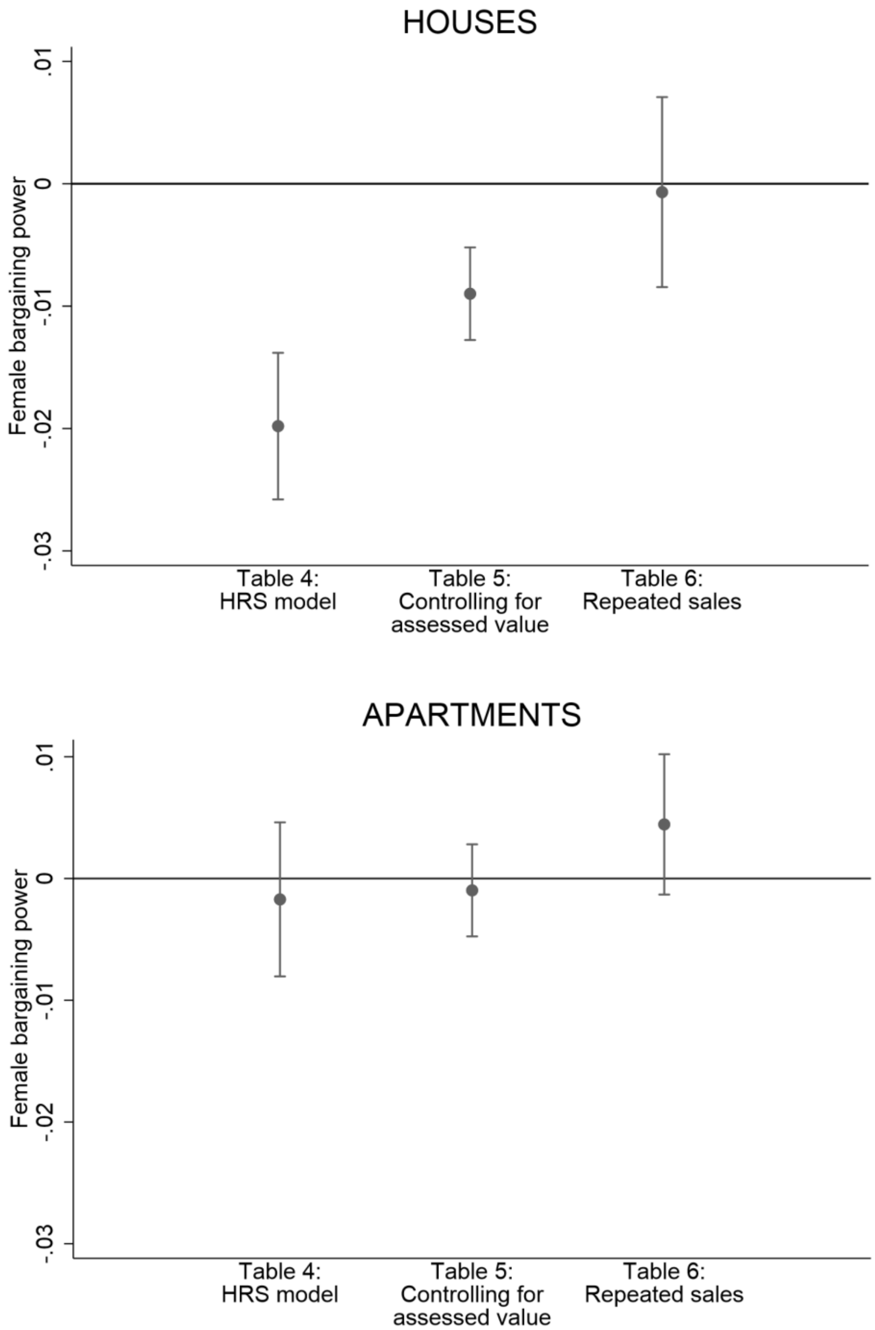

Table 1: Buyer and seller characteristics

This table shows mean characteristics of buyers and sellers in 337,685 property transactions from 1994 to 2013, in which both buyers and sellers are between 18 and 65 years of age and did not experience a change in the composition of adult household members around the time of transaction. Households consist of one or two adults living together and the number of children living with them. A household takes part in a transaction if at least one adult in the household buys or sells property. Buyers are identified as the owners of the property the year after the transaction, while sellers are identified as the owners of the property, registered January 1, in the year of the transaction. We take household characteristics from December 31 in the year before the transaction year. *Age* is the mean age of the adult household members. *Income* and *net wealth* are household totals in 2015 prices, winsorized at 1 percent in both ends, and presented in millions Danish kroner. *College* is the share of adult household members with a college degree. *Self-employed* is the share of adult household members that are self-employed. All shares take values 0, 0.5, or 1. *School-age children* is a dummy for having children between 5 and 15 years old (the children do not necessarily live in the household). *First-time buyer* is an indicator on no member of the household previously having owned real estate. *Out-of-town buyer* is an indicator on the household purchasing property in a municipality they did not previously live in. Standard deviations are presented in parentheses for non-indicator variables. *t-statistics* are in brackets. *** indicates significance at the 1% level. See Appendix Table D3 for differences in indicator variables.

	Buyers				Sellers			
	All	Single women (1)	Single men (2)	Difference (1)-(2)	All	Single women (3)	Single men (4)	Difference (3)-(4)
Age	38.83	41.86	36.66	5.20***	43.67	49.46	43.46	6.01***
	(11.36)	(12.21)	(11.62)	[55.4]	(11.82)	(11.69)	(12.19)	[67.21]
Income (million DKK)	0.67	0.36	0.38	-0.02***	0.66	0.34	0.39	-0.04***
	(0.39)	(0.23)	(0.27)	[-10.44]	(0.37)	(0.21)	(0.27)	[-24.50]
Net wealth (million DKK)	0.48	0.51	0.33	0.18***	0.63	0.80	0.54	0.26***
	(1.49)	(1.29)	(1.17)	[18.65]	(1.58)	(1.39)	(1.37)	[25.54]
College	0.28	0.34	0.20	0.14***	0.25	0.27	0.18	0.09***
				[40.65]				[28.69]
Self-employed	0.04	0.03	0.03	0.00	0.04	0.03	0.04	-0.01***
				[-1.28]				[-9.98]
School-age children	0.28	0.18	0.14	0.04***	0.30	0.14	0.19	-0.05***
				[12.39]				[-17.62]
First-time buyer	0.30	0.40	0.50	-0.10***				
				[-25.41]				
Out-of-town buyer	0.45	0.40	0.39	0.00				
				[0.97]				
N	337,685	28,720	36,232		337,685	35,007	36,413	

Table 2: Property characteristics

This table shows characteristics of property transactions from 1994 to 2013, separately for houses and apartments. *Price* is the realized sales price, and *assessed value* is the assessed value of the property from the Danish tax authorities prior to the sale. Both prices and assessed value are measured in thousand year-2015 DKK. (One Euro equals 7.45 DKK.) *Interior size and Lot size* are measured in square meters. *House age* and *building age* are measured in years. *Rooms* and *bathrooms* are count variables. *Rural* indicates a rural area. Standard deviations are presented in parentheses for non-indicator variables. *t-statistics* are in brackets. *** indicates significance at the 1% level.

		Buyers			Sellers		
	All	Single women (1)	Single men (2)	Difference (1)-(2)	Single women (3)	Single men (4)	Difference (3)-(4)
A. Houses							
Number of transactions	269,350	16,322	19,676		25,449	25,275	
Price (1,000 DKK)	1514.08	1185.41	1009.83	175.58***	1365.16	1236.70	128.46***
	(1097.75)	(900.89)	(912.03)	[18.28]	(1049.74)	(1018.74)	[13.98]
Assessed value (1,000 DKK)	1213.08	973.42	861.24	112.17***	1149.97	1053.08	96.89***
	(834.63)	(702.03)	(686.52)	[15.28]	(840.28)	(791.43)	[13.37]
Interior size (m^2)	121.46	100.81	99.47	1.34***	116.32	112.62	3.69***
	(45.89)	(36.72)	(38.00)	[3.37]	(45.44)	(45.68)	[9.12]
Lot size (m^2)	1030.20	794.18	970.11	-175.93***	1004.06	1087.06	-83.00***
	(2319.69)	(1137.47)	(1440.14)	[-12.67]	(1504.45)	(4290.55)	[-2.91]
House age (years)	45.01	53.05	56.92	-3.86***	50.68	52.21	-1.53***
	(35.16)	(40.78)	(41.15)	[-8.90]	(36.64)	(39.26)	[-4.54]
Rooms (#)	4.42	3.82	3.78	0.04***	4.28	4.15	0.12***
	(1.33)	(1.15)	(1.22)	[3.09]	(1.34)	(1.34)	[10.26]
Bathrooms (#)	1.38	1.18	1.16	0.03***	1.32	1.28	0.04***
	(0.56)	(0.44)	(0.44)	[5.66]	(0.55)	(0.53)	[8.66]
Rural	0.31	0.31	0.42	-0.11***	0.32	0.38	-0.06***
				[-22.15]			[-13.23]
B. Apartments							
Number of transactions	68,335	12,398	16,556		9,558	11,138	
Price (1,000 DKK)	1331.11	1207.52	1086.87	120.65***	1225.01	1125.28	99.73***
	(897.87)	(755.11)	(701.23)	[14.02]	(793.71)	(763.58)	[9.20]
Tax assessed value (1,000 DKK)	1082.95	976.23	892.46	83.77***	1001.14	921.57	79.57***
	(751.09)	(643.79)	(597.12)	[11.42]	(679.38)	(648.33)	[8.61]
Interior size (m^2)	76.43	71.91	69.02	2.88***	71.51	68.31	3.21***
	(29.61)	(22.85)	(23.55)	[10.45]	(26.63)	(27.24)	[8.53]
Building age (years)	63.55	61.61	61.47	0.14	63.89	63.34	0.55***
	(37.13)	(36.63)	(36.20)	[0.31]	(36.36)	(36.71)	[1.08]
Rooms (#)	2.67	2.52	2.38	0.14***	2.49	2.35	0.14***
	(1.06)	(0.89)	(0.89)	[13.44]	(1.00)	(0.98)	[10.49]
Bathrooms (#)	1.04	1.02	1.01	0.01***	1.03	1.02	0.01***
	(0.23)	(0.18)	(0.16)	[4.41]	(0.2)	(0.19)	[2.82]
Rural	0.02	0.01	0.01	0.00	0.01	0.01	0.00
				[-0.45]			[1.20]

Table 3: Hedonic model

This table shows gender differences in sales prices by buyer and seller characteristics using a simple hedonic regression. The dependent variable is the log of transaction price in thousand year-2015 DKK. Data covers property transactions from 1994 to 2013, in which both the buyer and seller are stable households with a member between 18 and 65 years of age. Column (1) contains only houses; (2) only apartments; and (3) both houses and apartments. Additional controls include property characteristics, location indicators, quarter fixed effects, and year fixed effects. Robust standard errors are reported in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively. The linear test of whether female buyers and sellers trade at the same price is reported in the bottom of the table as p-values of the test.

	Houses	Apartments	All
	(1)	(2)	(3)
Single female buyer	0.110***	0.075***	0.110***
	(0.005)	(0.004)	(0.005)
Single female seller	0.070***	0.071***	0.069***
	(0.004)	(0.005)	(0.004)
Single female buyer x apartment			-0.016**
			(0.006)
Single female seller x apartment			0.011
			(0.007)
Couple buyer	0.108***	0.020***	0.123***
	(0.004)	(0.004)	(0.004)
Couple seller	0.066***	0.004	0.065***
	(0.003)	(0.004)	(0.003)
Couple buyer x apartment			-0.108***
			(0.005)
Couple seller x apartment			-0.023***
			(0.005)
Buyer age	-0.003***	-0.002***	-0.003***
	(0.000)	(0.000)	(0.000)
Seller age	-0.000***	-0.003***	-0.001***
	(0.000)	(0.000)	(0.000)
Buyer income	0.336***	0.091***	0.268***
	(0.004)	(0.004)	(0.003)
Seller income	0.218***	0.164***	0.221***
	(0.003)	(0.005)	(0.003)
Buyer college	0.131***	0.122***	0.143***
	(0.002)	(0.003)	(0.002)
Seller college	0.060***	0.106***	0.082***
	(0.002)	(0.003)	(0.002)
Buyer selfemployed	0.059***	0.022***	0.050***
	(0.006)	(0.008)	(0.005)
Seller selfemployed	0.031***	0.002	0.028***
	(0.005)	(0.009)	(0.005)
Buyer kids x Q1	-0.021***	-0.066***	-0.029***
	(0.003)	(0.008)	(0.003)
Seller kids x Q1	-0.013***	-0.024***	-0.014***
	(0.003)	(0.007)	(0.003)
Buyer kids x Q2	-0.026***	-0.057***	-0.033***
	(0.003)	(0.007)	(0.003)
Seller kids x Q2	-0.009***	-0.013**	-0.013***
	(0.003)	(0.006)	(0.003)
Buyer kids x Q3	-0.033***	-0.066***	-0.038***
	(0.003)	(0.008)	(0.003)
Seller kids x Q3	-0.007**	-0.015**	-0.006**
	(0.003)	(0.007)	(0.003)
Buyer kids x Q4	-0.020***	-0.083***	-0.030***
	(0.006)	(0.013)	(0.005)
Seller kids x Q4	-0.010*	-0.021*	-0.009*
	(0.005)	(0.012)	(0.005)
First-time buyer	-0.030***	-0.006	-0.027***
	(0.002)	(0.004)	(0.002)
Out-of-town buyer	0.094***	0.084***	0.085***
	(0.002)	(0.003)	(0.002)
Apartment			0.045***
			(0.007)
Additional controls			
Tax assessement	No	No	No
Property characteristics	Yes	Yes	Yes
Location	Yes	Yes	Yes
Property fixed effects	No	No	No
Quarter fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
Pseudo R2	0.626	0.678	0.611
Number of observations	269,350	68,335	337,685
P-values for test of			
Single female buyer = Single female seller	0.000	0.500	0.000

Table 4: Gender differences in negotiation

This table shows gender differences in negotiation and demand using the estimation methodology of Harding, Rosenthal, and Sirmans (2003). The dependent variable is the log of transaction price in thousand year-2015 DKK. Data covers property transactions from 1994 to 2013, in which both the buyer and seller are stable households with a member between 18 and 65 years of age. Columns (1), (4), and (7) have the coefficients on the differences, i.e., the negotiation effects. Columns (2), (5), and (8) have the coefficients on the sums, i.e., the demand effects. Columns (3), (6), and (9) show other controls. Columns (1)–(3) contain only houses; (4)–(6), only apartments; and (7)–(9), both houses and apartments. Additional controls include: property characteristics, location indicators, quarter fixed effects, and year fixed effects. Robust standard errors are reported in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

	Houses			Apartments			All		
	Negotiation (1)	Demand (2)	Other controls (3)	Negotiation (4)	Demand (5)	Other controls (6)	Negotiation (7)	Demand (8)	Other controls (9)
Single female	-0.020***	0.091***		-0.002	0.073***		-0.021***	0.090***	
	(0.003)	(0.003)		(0.003)	(0.003)		(0.003)	(0.003)	
Single female x apartment							0.014***	-0.003	
							(0.005)	(0.005)	
Couple	-0.021***	0.087***		-0.007**	0.011***		-0.028***	0.094***	
	(0.002)	(0.002)		(0.003)	(0.003)		(0.002)	(0.002)	
Couple x apartment							0.043***	-0.066***	
							(0.004)	(0.004)	
Age	0.001***	-0.002***		-0.000***	-0.002***		0.001***	-0.002***	
	(0.000)	(0.000)		(0.000)	(0.000)		(0.000)	(0.000)	
Income	-0.061***	0.279***		0.035***	0.130***		-0.026***	0.246***	
	(0.003)	(0.002)		(0.003)	(0.003)		(0.002)	(0.002)	
College	-0.036***	0.097***		-0.010***	0.116***		-0.032***	0.113***	
	(0.002)	(0.002)		(0.002)	(0.002)		(0.001)	(0.001)	
Self-employed	-0.013***	0.044***		-0.010	0.011*		-0.011***	0.038***	
	(0.004)	(0.004)		(0.006)	(0.006)		(0.003)	(0.003)	
School-age children x 1st quarter	0.005**	-0.017***		0.021***	-0.046***		0.008***	-0.022***	
	(0.002)	(0.002)		(0.005)	(0.005)		(0.002)	(0.002)	
School-age children x 2nd quarter	0.009***	-0.018***		0.022***	-0.036***		0.010***	-0.024***	
	(0.002)	(0.002)		(0.005)	(0.005)		(0.002)	(0.002)	
School-age children x 3rd quarter	0.013***	-0.021***		0.026***	-0.042***		0.016***	-0.023***	
	(0.002)	(0.002)		(0.005)	(0.005)		(0.002)	(0.002)	
School-age children x 4th quarter	0.005	-0.015***		0.031***	-0.053***		0.011***	-0.020***	
	(0.004)	(0.004)		(0.009)	(0.009)		(0.004)	(0.003)	
First-time buyer			-0.032***			-0.008**			-0.029***
			(0.002)			(0.004)			(0.002)
Out-of-town buyer			0.093***			0.084***			0.085***
			(0.002)			(0.003)			(0.002)
Apartment									0.043***
									(0.007)
Constant			6.318***			5.920***			6.225***
			(0.008)			(0.014)			(0.008)
Additional controls:									
Property characteristics		Yes			Yes			Yes	
Location		Yes			Yes			Yes	
Property fixed effects		No			No			No	
Quarter fixed effects		Yes			Yes			Yes	
Year fixed effects		Yes			Yes			Yes	
Pseudo R2		0.626			0.679			0.611	
Number of observations		269,350			68,335			337,685	

Table 5: Gender differences in negotiation controlling for tax-assessed value

This table shows gender differences in negotiation and demand using the estimation methodology of Harding, Rosenthal, and Sirmans (2003), adding controls for the tax-assessed value of the property. The dependent variable is the log of transaction price in thousand year-2015 DKK. Data covers property transactions from 1994 to 2013, in which both the buyer and seller are stable households with a member between 18 and 65 years of age. Columns (1), (4), and (7) have the coefficients on the differences, i.e., the negotiation effects. Columns (2), (5), and (8) have the coefficients on the sums, i.e., the demand effects. Columns (1)–(3) contain only houses; (4)–(6), only apartments; and (7)–(9), both houses and apartments. Additional controls include: property characteristics, location indicators, quarter fixed effects, and year fixed effects. Robust standard errors are reported in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

	Houses			Apartments			All		
	Negotiation	Demand	Other controls	Negotiation	Demand	Other controls	Negotiation	Demand	Other controls
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Single female	-0.010***	0.053***		-0.001	0.026***		-0.010***	0.053***	
	(0.002)	(0.002)		(0.002)	(0.002)		(0.002)	(0.002)	
Single female x apartment							0.007**	-0.026***	
							(0.003)	(0.003)	
Couple	0.006***	0.073***		0.002	0.006***		0.004**	0.075***	
	(0.002)	(0.001)		(0.002)	(0.002)		(0.002)	(0.001)	
Couple x apartment							0.005**	-0.074***	
							(0.002)	(0.002)	
Age	-0.000***	-0.001***		-0.000***	-0.001***		-0.000***	-0.001***	
	(0.000)	(0.000)		(0.000)	(0.000)		(0.000)	(0.000)	
Income	-0.020***	0.079***		0.018***	0.045***		-0.006***	0.069***	
	(0.001)	(0.001)		(0.002)	(0.002)		(0.001)	(0.001)	
College	-0.014***	0.026***		-0.008***	0.025***		-0.014***	0.026***	
	(0.001)	(0.001)		(0.001)	(0.001)		(0.001)	(0.001)	
Self-employed	-0.006**	0.019***		0.001	0.001		-0.003	0.014***	
	(0.002)	(0.002)		(0.004)	(0.004)		(0.002)	(0.002)	
School-age children x 1st quarter	-0.002	-0.017***		0.003	-0.026***		-0.000	-0.016***	
	(0.001)	(0.001)		(0.003)	(0.003)		(0.001)	(0.001)	
School-age children x 2nd quarter	-0.004***	-0.019***		0.002	-0.024***		-0.002**	-0.019***	
	(0.001)	(0.001)		(0.003)	(0.003)		(0.001)	(0.001)	
School-age children x 3rd quarter	-0.001	-0.019***		0.007**	-0.025***		0.001	-0.019***	
	(0.001)	(0.001)		(0.003)	(0.003)		(0.001)	(0.001)	
School-age children x 4th quarter	-0.004	-0.016***		0.010**	-0.030***		-0.001	-0.017***	
	(0.002)	(0.002)		(0.005)	(0.005)		(0.002)	(0.002)	
First-time buyer			-0.008***			0.001			-0.007***
			(0.001)			(0.002)			(0.001)
Out-of-town buyer			0.017***			0.019***			0.018***
			(0.001)			(0.002)			(0.001)
Apartment									0.086***
									(0.004)
Assessed value (log)			0.917***			0.883***			0.914***
			(0.003)			(0.004)			(0.002)
Constant			0.643***			0.940***			0.675***
			(0.019)			(0.023)			(0.015)
Additional controls:									
Property characteristics		Yes			Yes			Yes	
Location		Yes			Yes			Yes	
Property fixed effects		No			No			No	
Quarter fixed effects		Yes			Yes			Yes	
Year fixed effects		Yes			Yes			Yes	
Pseudo R2		0.869			0.891			0.871	
Number of observations		269,350			68,335			337,685	

Table 6: Repeated sales

This table presents results where we control for time invariant unobserved heterogeneity by including property fixed effect within a repeated sales sample, still using the estimation methodology of Harding, Rosenthal, and Sirmans (2003). The dependent variable is the log of transaction price in thousand year-2015 DKK. Data covers property transactions from 1994 to 2013, in which both the buyer and seller are stable households with a member between 18 and 65 years of age, and the property is traded more than once during the time period. Columns (1), (4), and (7) have the coefficients on the differences, i.e., the negotiation effects. Columns (2), (5), and (8) have the coefficients on the sums, i.e., the demand effects. Columns (1)–(3) contain only houses; (4)–(6), only apartments; and (7)–(9), both houses and apartments. Additional controls include: quarter fixed effects, and year fixed effects. Robust standard errors are reported in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

	Houses			Apartments			All		
	Negotiation (1)	Demand (2)	Other controls (3)	Negotiation (4)	Demand (5)	Other controls (6)	Negotiation (7)	Demand (8)	Other controls (9)
Single female	-0.001	0.039***		0.004	0.011***		-0.000	0.035***	
	(0.004)	(0.005)		(0.003)	(0.004)		(0.004)	(0.005)	
Single female x apartment							0.003	-0.022***	
							(0.005)	(0.006)	
Couple	0.027***	0.059***		0.009***	-0.000		0.026***	0.058***	
	(0.003)	(0.004)		(0.003)	(0.003)		(0.003)	(0.004)	
Couple x apartment							-0.019***	-0.061***	
							(0.004)	(0.005)	
Age	-0.000***	-0.001***		-0.001***	-0.001***		-0.000***	-0.001***	
	(0.000)	(0.000)		(0.000)	(0.000)		(0.000)	(0.000)	
Income	-0.016***	0.043***		-0.002	0.015***		-0.011***	0.031***	
	(0.002)	(0.003)		(0.003)	(0.003)		(0.002)	(0.002)	
College	-0.010***	0.008***		-0.009***	0.010***		-0.011***	0.009***	
	(0.002)	(0.003)		(0.002)	(0.003)		(0.001)	(0.002)	
Self-employed	0.004	0.013**		-0.011**	-0.007		0.001	0.007*	
	(0.004)	(0.005)		(0.005)	(0.007)		(0.004)	(0.004)	
School-age children x 1st quarter	-0.006**	-0.010***		0.001	-0.022***		-0.005**	-0.011***	
	(0.003)	(0.003)		(0.005)	(0.005)		(0.002)	(0.002)	
School-age children x 2nd quarter	-0.007***	-0.006**		-0.006	-0.011**		-0.007***	-0.008***	
	(0.002)	(0.003)		(0.005)	(0.005)		(0.002)	(0.002)	
School-age children x 3rd quarter	-0.008***	-0.009***		0.008*	-0.012**		-0.005*	-0.011***	
	(0.003)	(0.003)		(0.005)	(0.005)		(0.003)	(0.003)	
School-age children x 4th quarter	-0.009*	-0.007		-0.001	-0.017*		-0.008*	-0.011**	
	(0.005)	(0.005)		(0.009)	(0.009)		(0.005)	(0.004)	
First-time buyer			0.000			-0.003			-0.003
			(0.002)			(0.004)			(0.002)
Out-of-town buyer			0.018***			0.003			0.014***
			(0.002)			(0.003)			(0.002)
Assessed value (log)			0.572***			0.517***			0.558***
			(0.011)			(0.010)			(0.008)
Constant			3.034***			3.522***			3.175***
			(0.078)			(0.067)			(0.054)
Additional controls:									
Property characteristics		No			No			No	
Location		No			No			No	
Property fixed effects		Yes			Yes			Yes	
Quarter fixed effects		Yes			Yes			Yes	
Year fixed effects		Yes			Yes			Yes	
Pseudo R2		0.700			0.843			0.735	
Number of observations		71,417			25,799			97,216	

Table 7: Property characteristics of death sales

This table shows characteristics of properties sold after the death of the owner in the years 1994 to 2013, separately for houses and apartments. *Price* is the realized sale price, and *assessed value* is the assessed value of the property from the Danish tax authorities prior to the sales. Both prices and assessed value are measured in thousand year-2015 DKK. *Interior size and Lot size* are measured in square meters. *House age* and *building age* are measured in years. *Rooms* and *bathrooms* are count variables. *Rural* indicates a rural area. Standard deviations are presented in parentheses for non-indicator variables. *t-statistics* are in brackets. *** and ** indicate significance at the 1% and 5% levels, respectively.

		Sellers		
	All	Women (1)	Men (2)	Difference (1)-(2)
A. Houses				
Number of transactions	12,633	1,667	1,929	
Price (1,000 DKK)	1208.83	1273.27	1187.81	85.46***
	(899.52)	(987.47)	(925.35)	[2.68]
Assessed value (1,000 DKK)	1145.24	1231.85	1174.58	57.28*
	(822.25)	(883.52)	(891.54)	[1.93]
Interior size (m^2)	112.57	113.38	111.12	2.27*
	(37.61)	(39.35)	(38.12)	[1.75]
Lot size (m^2)	1001.19	1035.33	984.56	50.78
	(2289.26)	(2760.94)	(890.38)	[0.76]
House age (years)	55.11	57.35	56.92	0.42
	(33.51)	(35.54)	(34.2)	[0.36]
Rooms (#)	4.12	4.18	4.10	0.09**
	(1.19)	(1.26)	(1.17)	[2.10]
Bathrooms (#)	1.24	1.27	1.23	0.04**
	(0.49)	(0.54)	(0.48)	[2.33]
Rural	0.24	0.24	0.26	-0.02
				[-1.39]
B. Apartments				
Number of transactions	1,320	240	195	
Price (1,000 DKK)	1252.69	1189.94	1271.71	-81.77
	(844.76)	(810.34)	(856.59)	[-1.02]
Assessed value (1,000 DKK)	1162.78	1135.50	1152.69	-17.20
	(814.31)	(787.91)	(718.3)	[-0.24]
Interior size (m^2)	82.68	81.70	82.04	-0.34
	(26.42)	(27.68)	(27.99)	[-0.13]
Building age (years)	50.53	55.05	54.26	0.79
	(33.71)	(32.76)	(38.21)	[0.23]
Rooms (#)	2.91	2.85	2.90	-0.05
	(0.99)	(1.03)	(1.02)	[-0.49]
Bathrooms (#)	1.05	1.04	1.03	0.01
	(0.24)	(0.23)	(0.19)	[0.58]
Rural	0.02	0.03	0.01	0.02
				[1.38]

Table 8: Hedonic model when selling inherited properties

This table shows gender differences in sales prices by buyer and seller characteristics when selling inherited properties using a simple hedonic regression. The dependent variable is the log of transaction price in thousand year-2015 DKK. Data covers property transactions from 1994 to 2013, in which both the buyer and seller are stable households with a member between 18 and 65 years of age. Column (1) contains only houses; (2) only apartments; and (3) both houses and apartments. Additional controls include *couple buyer* and *couple seller*, buyer and seller characteristics, property characteristics, location indicators, quarter fixed effects, and year fixed effects. Only coefficients on the variable of interest, female buyers and female sellers, are reported. Robust standard errors are reported in parentheses. *** indicates statistical significance at the 1% level. The linear test of whether female buyers and sellers trade at the same price is reported in the bottom of the table as p-values of the test.

	Houses	**Apartment**	**All**
	(1)	(2)	(3)
Single female buyer	0.036***	0.004	0.036***
	(0.010)	(0.020)	(0.010)
Single female seller	0.014	-0.016	0.014
	(0.011)	(0.022)	(0.011)
Single female buyer x apartment			-0.031
			(0.022)
Single female seller x apartment			-0.040
			(0.026)
Additional controls			
Buyer and seller characteristics	Yes	Yes	Yes
Assessed value	Yes	Yes	Yes
Property characteristics	Yes	Yes	Yes
Location	Yes	Yes	Yes
Property fixed effects	No	No	No
Quarter fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
Pseudo R2	0.840	0.836	0.837
Number of observations	12,633	1,320	13,953
P-values for test of *Single female buyer = Single female seller*	0.143	0.486	0.149

Online Appendix for "Gender Differences in Negotiation: Evidence from Real Estate Transactions"

Appendix A: Data Construction

Data sources

We combine data from several administrative registers in Denmark, all made available to us by Statistics Denmark. Each property (whether a house or an apartment) is registered in the Housing Register (*Bygnings- og Boligregister*, BBR) and can be followed using a unique identification code. The register contains all properties in Denmark, and gives detailed information about the characteristics of each property.

Property transactions have to be announced in the Danish Gazette (*Statstidende*), along with the transaction value, and the personal identification number (*CPR-nummer*) of the current owner, as well as the property identification number used in BBR. These two IDs enable us to link each transaction to sellers and buyers over time. We identify buyers as the owners of the property on January 1 in the year after the transaction, while sellers are identified as the owners of the property on January 1 in the year of the transaction.[1]

The Danish tax authorities (SKAT) assess the value of properties, which forms the basis for the property value tax and the municipality land tax. The assessment is carried out every other year and is an estimate of the property's value if it were to be sold. The valuation takes into account factors such as local market conditions, an array of house characteristics, and permissible alternative uses of the land. In years in which a house is not assessed by the tax authorities, the value is regulated based on the growth in local house prices in the period following the most recent assessment. As the assessment is carried out at the municipality level, it might incorporate factors that are unobserved in the data from BBR. The assessment of house values by the tax authorities therefore provides us with a house-specific estimate of the expected price.

To control for other characteristics of buyers and sellers, which might influence negotiation outcomes, such as education, income, and family composition, we link several other administrative registers using the personal identification number. We use the civil registration system (CPR register) to identify age, gender, and marital status of all buyers and sellers. We use educational information from the Ministry of Education to identify the level of education of each individual, and we use the employment register (IDA) to identify

[1] In cases where the sales agreement is signed in year t, but ownership is not transferred until year $t+1$, we identify the buyers as owners on January 1 in year $t+2$, conditional on no registered trades of the property during year $t+1$.

each individual's employment status. Additionally, we use income and wealth reported by third parties to the Danish Tax and Customs Administration (SKAT) to identify income and wealth of each individual.

Sample selection

Our data contain all property transactions in Denmark from 1994 to 2013. In the empirical analysis, we restrict the sample to single-family houses and apartments, which are bought and sold by individuals. We drop transactions that are flagged by Statistics Denmark as involving price clauses or extreme prices, and properties that are rented out. To ensure correct identification of buyers and sellers, we exclude properties that are traded more than once within a year. Transactions between members of the same household or between parents and children are also excluded, as are transactions for which data on buyer or seller are missing.

We impose the criterion that the buying and selling household remains stable in the transaction year and in the year after transaction. A household is considered stable if the number of adults remains constant, implying that observations in which two singles moving in together and becoming a joint household or a couple splitting up and becoming two new households are excluded from our data. For the same reason, we also exclude a) transactions involving households that experienced a divorce in the period from two years before to one year after the transaction date, and b) transactions involving households that lost an adult member to death within one year before or after the transaction.

To avoid speculative behavior, we drop transactions that include households who buy more than three properties in a year, or sell more than three households in a year. Last, we restrict the sample to transactions conducted between agents of 18 to 65 years of age.

These refinements leave us with 337,685 transactions of residential real estate.

Death data

In section 4, we analyze gender differences in negotiation using a sample of death sales. The death data are constructed by linking the Cause-of-Death Register from the Danish National Board of Health (*Sundhedsstyrelsen*) to the Danish Civil Registration System (*CPR*)*,* which allows us to identify all household terminations in our sample period. A household termination is the death of the only individual in a one-member household, i.e., a single, widowed, or divorced individual. To study the following sale of inherited real estate, we focus on individuals who owned real estate at the time of death. We then link to the register of property transactions to establish the timing of a following sale. By law, the settlement of the estate has to take place within a year from the death, but, as extensions are possible, we keep transactions that take place within 1.5 years of the death.

To identify the beneficiaries who are in charge of selling the property, we use the social security number (*CPR*) to establish the link to all the children of the deceased. We restrict the sample to household terminations with exactly one child, to ensure that we can identify the decision maker in the selling process.

Copying the sample selection approach for the full sample, we combine data from several registers to characterize the beneficiary (i.e., seller) in terms of family type, age, income, and education. We also merge on the buyer information obtained in the full sample.

In addition, we apply all the selection criteria of the full sample to the death sales sample, leaving us with 13,953 death sales.

Variable definition

The dependent variable is the log of the transaction price in thousand year-2015 DKK. The hedonic model includes the following property characteristics: indicator for *apartment*, *interior size* (in square meters), *lot size* (in square meters), *number of rooms, number of bathrooms, age of the building* (in years), indicator for *rural area,* and indicators for *municipality population size.* All variables are from the BBR register, except for the control for rural area, which is from a separate land register. In addition, we introduce the log of the assessed value (measured in thousand year-2015 DKK) from the tax authorities as additional control from Table 5 and onward.

We characterize the buyer and seller households using the unique household ID created by Statistics Denmark. According to the definition used by Statistics Denmark, households consist of one or two adults and the number of children (under the age of 25) living with them. We define three types of households: couples, single women, and single men. Couples cover both married, registered, and cohabiting partners, as defined by Statistics Denmark.

Household characteristics are from December 31 of the year previous to the trade year. *Age* is average age of adult household members and is measured in years. *Income* is total income in million year-2015 DKK, winsorized at the values of the 1 and 99 percentiles. *College, Unemployed,* and *Self-employed* all take the values 0, 0.5, or 1, and indicate the share of adult household members who have a college degree, are unemployed, or are self-employed, respectively. All employment indicators are from November in the year before the transaction.

School-age children is an indicator for having children between 5 and 15 years old (the children do not necessarily live in the household). Following the specification in HRS, we interact the indicator for school-age children with the quarter of the transaction. *First-time buyer* indicates that no one in the buyer household has previously owned real estate. *Out-of-town buyer* denotes that the buyer lived in another municipality before buying.

Appendix B: A Model of Household Negotiation

This Appendix details the challenge of separating negotiation effects from demand effects and discusses the solution suggested by Harding, Rosenthal, and Sirmans (2003) (henceforth HRS).

The market for heterogeneous goods, like the housing market, is often too thin to have a clear market price. Instead, room exists for negotiation, leaving the price to be determined by the negotiation between the buyer and the seller. HRS develop a model for identifying characteristics-specific negotiation of agents.

The price of a heterogeneous good can be described by a hedonic price model (Rosen, 1974). A good X is defined by a set of characteristics C, where $X=X(C)$. The market price of X is the product of C and a vector of shadow prices $s(C)$:

$$P = s(C) \cdot C \qquad (1)$$

For most heterogeneous goods, s is not directly observed, but as long as markets are sufficiently thick, market participants can determine s, and s is still well-defined (Rosen, 1974). However, as goods become more heterogeneous, the market becomes thinner. In the case of the housing market, almost no houses are alike, making each transaction unique. When the transaction is unique, s is not well-known. Because the requirements for perfect competition are not met, excess surplus is not necessarily driven to zero. The buyer's willingness to pay may be larger than the seller's willingness to accept, leaving excess surplus to be distributed between the buyer and the seller. The trading partners will distribute this surplus through negotiating over the price. HRS adds negotiation to the hedonic price model, now defining individual transaction i:

$$P_i = sC_i + B_i. \qquad (2)$$

sC_i is the implicit market price of house i, which depends on the house characteristic. B_i is the deviation from the market price, due to negotiation, which depends on the characteristics of the buyer and the seller. If B_i is positive, the seller benefits from negotiation, and if B_i is negative, the buyer benefits. That is, B_i reflects the relative bargaining power of the buyer and the seller, and will be a function of buyer and seller characteristics. HRS remove the subscripts for simplicity and express B as

$$B = b^{sell} D^{sell} + b^{buy} D^{buy} + e_B , \qquad (3)$$

where D^{sell} and D^{buy} are vectors of the seller and buyer characteristics, respectively. b^{sell} and b^{buy} are vectors of coefficients that describe the impact of seller and buyer characteristics on negotiation. e_B is idiosyncratic differences in negotiation. Substituting (3) into (2) gives

$$P = sC + b^{sell} D^{sell} + b^{buy} D^{buy} + e_B , \qquad (4)$$

where b^{sell} and b^{buy} measure the effect of negotiation on the transaction price.

To use equation (4) to analyze gender differences in negotiation, we need to include all relevant house characteristics in C and ensure that any unobserved characteristics are uncorrelated with the characteristics of the buyer and seller. In practice, it is difficult to ensure that the specification controls for all relevant characteristics. For instance, if women in general buy houses with higher amenity values, and amenity values are unobserved in the data, the results will imply that women pay more than men for the same house, when in fact they pay more due to the amenity value. In that case, we would attribute the difference in amenity value to gender differences in negotiation, rather than to differences in demand.

If C is fully observed by market participants but only partly observed by us, we need further measures to ensure identification of negotiation. Harding, Rosenthal, and Sirmans (2003) assume that C_1 is observed by the researcher, but C_2 is not. Different buyers and sellers may value C_2 differently, which cause C_2 to be correlated with D^{sell} and D^{buy}. The demand for the unobserved characteristics of the house is

$$s_2C_2 = d^{sell}\,D^{sell} + d^{buy}\,D^{buy} + e_D \qquad (5)$$

where s_2 is the vector of shadow prices on the unobserved characteristic, and e_D is idiosyncratic differences in preferences across individuals. Problematically, individual characteristics that affect negotiation also influence demand for unobserved attributes of the house. If we substitute (5) into (4) and rearrange, we cannot identify negotiation effects separately from demand effects:

$$P = s_1C_1 + (\,b^{sell} + d^{sell})\,D^{sell} + (\,b^{buy} + d^{buy}\,)\,D^{buy} + \varepsilon \qquad (6)$$

where $\varepsilon = e_B + e_D$.

We need restrictions on bs and ds in order to identify negotiation. Harding, Rosenthal, and Sirmans (2003) suggests two symmetry assumptions:

i) Symmetric bargaining power: $b^{sell} = -\,b^{buy}$

ii) Symmetric demand: $d^{sell} = d^{buy}$

Assumption i) implies that if buyers and sellers have identical characteristics, they will have the same bargaining power, i.e., neither will have an advantage. Assumption ii) implies that if buyers and sellers are identical, they value the houses equally, i.e., they have the same demand for houses. These two symmetry assumptions cannot be tested.

Appling i) and ii) to (6) gives us

$$P = s_1C_1 + b\,(D^{sell} - D^{buy}) + d\,(D^{sell} + D^{buy}) + \varepsilon\,, \qquad (7)$$

which is easily estimated by Ordinary Least Squares (OLS). If i) and ii) hold, then *b* will be a measure of the effect of buyer and seller characteristics on bargaining power, independent of differences in demand.

A positive *b* reflects a negotiation advantage, and a negative *b* reflects a negotiation disadvantage. That is, if the coefficient to $(woman^{sell} - woman^{buy})$ is positive, the price is higher when women are sellers or lower when women are buyers. Both reflect a good negotiation outcome for women. If the coefficient to $(woman^{sell} - woman^{buy})$ is negative, then the price is lower when women are sellers or higher when women are buyers. Both reflect a poor negotiation outcome for women.

Importantly, we only have identification from transactions that involve different agents on buyers' and sellers' sides, otherwise $(D^{sell} - D^{buy})$ will be zero. In the case of gender, identification comes from transactions involving different genders and not from transactions in which the buyer and seller are the same gender.

Demand for unobserved characteristics of the house, like amenity value, appears in the demand effect *d,* which captures differences in demand between different types of households.

We estimate negotiation, using pooled OLS and robust standard errors, by means of the following equation:

$$Ln\ (price_{it}) = \beta_0 + s\ C_i + b\ (D_i^{sell} - D_i^{buy}) + d\ (D_i^{sell} + D_i^{buy}) + quarter_i + year_i + u_i\ , \qquad (8)$$

where *price* is the transaction value, C_i is a vector of observed property characteristics, and D_i^{sell} and D_i^{buy} are vectors of seller and buyer characteristics. $quarter_i$ is a vector of quarter dummies, and $year_i$ is a vector of year dummies*,* both describing the timing of the transaction. Note that Equation (8) corresponds to Equation (1) in the manuscript where we have formalized the notation by referring to the dependent variable as y and fixed effects as alphas.

Because we take the log of the price, b^{woman} is the gender difference in negotiation, and a positive coefficient indicates bargaining advantage of women measured in percent.

Appendix C: Adding wealth control

Table C1: Gender differences in negotiation (Table 4 with wealth control)

This table shows gender differences in negotiation and demand using the estimation methodology of Harding, Rosenthal, and Sirmans (2003), and adding wealth controls. The dependent variable is the log of transaction price in thousand year-2015 DKK. Data covers property transactions from 1994 to 2013, in which both the buyer and seller are stable households with a member between 18 and 65 years of age. Columns (1), (4), and (7) have the coefficients to the differences, i.e., the negotiation effects. Columns (2), (5), and (8) have the coefficients to the sums, i.e., the demand effects. Columns (1)–(3) contain only houses; (4)–(6), only apartments; and (7)–(9), both houses and apartments. Additional controls include: property characteristics, location indicators, quarter fixed effects, and year fixed effects. Robust standard errors are reported in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

	Houses			**Apartments**			**All**		
	Negotiation (1)	Demand (2)	Buyers only (3)	Negotiation (4)	Demand (5)	Buyers only (6)	Negotiation (7)	Demand (8)	Buyers only (9)
Single female	-0.020***	0.090***		-0.002	0.073***		-0.020***	0.089***	
	(0.003)	(0.003)		(0.003)	(0.003)		(0.003)	(0.003)	
Single female x apartment							0.014***	-0.002	
							(0.005)	(0.005)	
Couple	-0.022***	0.093***		-0.008***	0.012***		-0.029***	0.099***	
	(0.002)	(0.002)		(0.003)	(0.003)		(0.002)	(0.002)	
Couple x apartment							0.043***	-0.067***	
							(0.004)	(0.004)	
Age	0.002***	-0.003***		-0.000*	-0.002***		0.002***	-0.003***	
	(0.000)	(0.000)		(0.000)	(0.000)		(0.000)	(0.000)	
Income	-0.055***	0.253***		0.040***	0.122***		-0.021***	0.223***	
	(0.003)	(0.002)		(0.003)	(0.003)		(0.002)	(0.002)	
Net wealth	-0.006***	0.021***		-0.004***	0.007***		-0.004***	0.019***	
	(0.001)	(0.001)		(0.001)	(0.001)		(0.000)	(0.000)	
College	-0.038***	0.098***		-0.011***	0.117***		-0.033***	0.115***	
	(0.002)	(0.002)		(0.002)	(0.002)		(0.001)	(0.001)	
Self-employed	-0.015***	0.045***		-0.011*	0.010*		-0.012***	0.038***	
	(0.004)	(0.004)		(0.006)	(0.006)		(0.003)	(0.003)	
School-age children x 1st quarter	0.003	-0.012***		0.020***	-0.044***		0.007***	-0.017***	
	(0.002)	(0.002)		(0.005)	(0.005)		(0.002)	(0.002)	
School-age children x 2nd quarter	0.007***	-0.014***		0.021***	-0.034***		0.009***	-0.019***	
	(0.002)	(0.002)		(0.005)	(0.005)		(0.002)	(0.002)	
School-age children x 3rd quarter	0.012***	-0.016***		0.025***	-0.040***		0.016***	-0.018***	
	(0.002)	(0.002)		(0.005)	(0.005)		(0.002)	(0.002)	
School-age children x 4th quarter	0.004	-0.011***		0.030***	-0.051***		0.010***	-0.016***	
	(0.004)	(0.004)		(0.009)	(0.009)		(0.004)	(0.003)	
First-time buyer			-0.032***			-0.007*			-0.028***
			(0.002)			(0.004)			(0.002)
Out-of-town buyer			0.093***			0.082***			0.084***
			(0.002)			(0.003)			(0.002)
Apartment								0.037***	
								(0.006)	
Constant		6.390***			5.941***			6.289***	
		(0.008)			(0.014)			(0.008)	
Additional controls:									
Property characteristics		Yes			Yes			Yes	
Location		Yes			Yes			Yes	
Property fixed effects		No			No			No	
Quarter fixed effects		Yes			Yes			Yes	
Year fixed effects		Yes			Yes			Yes	
Pseudo R2		0.630			0.680			0.614	
Number of observations		269,350			68,335			337,685	

Table C2: Gender differences in negotiation controlling for assessed value (Table 5 with wealth control)

This table shows gender differences in negotiation and demand using the estimation methodology of Harding, Rosenthal, and Sirmans (2003), adding controls for the tax-assessed value of the property and wealth. The dependent variable is the log of transaction price in thousand year-2015 DKK. Data covers property transactions from 1994 to 2013, in which both the buyer and seller are stable households with a member between 18 and 65 years of age. Columns (1), (4), and (7) have the coefficients to the differences, i.e., the negotiation effects. Columns (2), (5), and (8) have the coefficients to the sums, i.e., the demand effects. Columns (1)–(3) contain only houses; (4)–(6), only apartments; and (7)–(9), both houses and apartments. Additional controls include: property characteristics, location indicators, quarter fixed effects, and year fixed effects. Robust standard errors are reported in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

	Houses			Apartments			All		
	Negotiation	Demand	Buyers only	Negotiation	Demand	Buyers only	Negotiation	Demand	Buyers only
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Single female	-0.009***	0.053***		-0.001	0.026***		-0.009***	0.053***	
	(0.002)	(0.002)		(0.002)	(0.002)		(0.002)	(0.002)	
Single female x apartment							0.007**	-0.026***	
							(0.003)	(0.003)	
Couple	0.005***	0.071***		0.002	0.005***		0.003*	0.073***	
	(0.002)	(0.001)		(0.002)	(0.002)		(0.002)	(0.001)	
Couple x apartment							0.006**	-0.074***	
							(0.002)	(0.002)	
Age	0.000***	-0.001***		-0.000***	-0.001***		0.000***	-0.001***	
	(0.000)	(0.000)		(0.000)	(0.000)		(0.000)	(0.000)	
Income	-0.014***	0.084***		0.019***	0.047***		-0.002*	0.074***	
	(0.001)	(0.001)		(0.002)	(0.002)		(0.001)	(0.001)	
Net wealth	-0.006***	-0.004***		-0.002***	-0.002***		-0.005***	-0.004***	
	(0.000)	(0.000)		(0.000)	(0.000)		(0.000)	(0.000)	
College	-0.014***	0.026***		-0.009***	0.024***		-0.014***	0.026***	
	(0.001)	(0.001)		(0.001)	(0.001)		(0.001)	(0.001)	
Self-employed	-0.006***	0.019***		0.001	0.001		-0.003	0.015***	
	(0.002)	(0.002)		(0.004)	(0.004)		(0.002)	(0.002)	
School-age children x 1st quarter	-0.003**	-0.017***		0.003	-0.027***		-0.001	-0.017***	
	(0.001)	(0.001)		(0.003)	(0.003)		(0.001)	(0.001)	
School-age children x 2nd quarter	-0.005***	-0.020***		0.002	-0.024***		-0.004***	-0.020***	
	(0.001)	(0.001)		(0.003)	(0.003)		(0.001)	(0.001)	
School-age children x 3rd quarter	-0.003*	-0.019***		0.006**	-0.026***		-0.000	-0.019***	
	(0.001)	(0.001)		(0.003)	(0.003)		(0.001)	(0.001)	
School-age children x 4th quarter	-0.005**	-0.016***		0.010*	-0.030***		-0.002	-0.018***	
	(0.002)	(0.002)		(0.005)	(0.005)		(0.002)	(0.002)	
First-time buyer			-0.008***			0.001			-0.007***
			(0.001)			(0.002)			(0.001)
Out-of-town buyer			0.017***			0.019***			0.018***
			(0.001)			(0.002)			(0.001)
Apartment								0.088***	
								(0.004)	
Assessed value (log)		0.922***			0.884***			0.917***	
		(0.003)			(0.004)			(0.002)	
Constant		0.601***			0.930***			0.640***	
		(0.019)			(0.023)			(0.015)	
Additional controls:									
Property characteristics		Yes			Yes			Yes	
Location		Yes			Yes			Yes	
Property fixed effects		No			No			No	
Quarter fixed effects		Yes			Yes			Yes	
Year fixed effects		Yes			Yes			Yes	
Pseudo R2		0.870			0.891			0.871	
Number of observations		269,350			68,335			337,685	

Table C3: Repeated sales (Table 6 with wealth control)

This table presents results where we control for time invariant unobserved heterogeneity by including property fixed effect within a repeated sales sample, adding wealth controls. The dependent variable is the log of transaction price in thousand year-2015 DKK. Data covers property transactions from 1994 to 2013, in which both the buyer and seller are stable households with a member between 18 and 65 years of age, and the property is traded more than once during the time period. Columns (1), (4), and (7) have the coefficients to the differences, i.e., the negotiation effects. Columns (2), (5), and (8) have the coefficients to the sums, i.e., the demand effects. Columns (1)–(3) contain only houses; (4)–(6), only apartments; and (7)–(9), both houses and apartments. Additional controls include: quarter fixed effects and year fixed effects. Robust standard errors are reported in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

	Houses			Apartments			All		
	Negotiation	Demand	Buyers only	Negotiation	Demand	Buyers only	Negotiation	Demand	Buyers only
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Single female	-0.001	0.039***		0.004	0.012***		0.000	0.035***	
	(0.004)	(0.005)		(0.003)	(0.004)		(0.004)	(0.005)	
Single female x apartment							0.003	-0.022***	
							(0.005)	(0.006)	
Couple	0.027***	0.058***		0.008***	-0.001		0.026***	0.058***	
	(0.003)	(0.004)		(0.003)	(0.003)		(0.003)	(0.004)	
Couple x apartment							-0.019***	-0.060***	
							(0.004)	(0.005)	
Age	-0.000***	-0.001***		-0.001***	-0.001***		-0.000***	-0.001***	
	(0.000)	(0.000)		(0.000)	(0.000)		(0.000)	(0.000)	
Income	-0.015***	0.045***		-0.000	0.017***		-0.009***	0.033***	
	(0.002)	(0.003)		(0.003)	(0.003)		(0.002)	(0.002)	
Net wealth	-0.002***	-0.003***		-0.001**	-0.002***		-0.001***	-0.003***	
	(0.001)	(0.001)		(0.001)	(0.001)		(0.000)	(0.001)	
College	-0.010***	0.008***		-0.009***	0.009***		-0.011***	0.009***	
	(0.002)	(0.003)		(0.002)	(0.003)		(0.001)	(0.002)	
Self-employed	0.004	0.013**		-0.011**	-0.007		0.000	0.007	
	(0.004)	(0.005)		(0.005)	(0.007)		(0.004)	(0.004)	
School-age children x 1st quarter	-0.006**	-0.010***		0.001	-0.022***		-0.005**	-0.011***	
	(0.003)	(0.003)		(0.005)	(0.005)		(0.002)	(0.002)	
School-age children x 2nd quarter	-0.007***	-0.007***		-0.006	-0.012**		-0.007***	-0.009***	
	(0.002)	(0.003)		(0.005)	(0.005)		(0.002)	(0.002)	
School-age children x 3rd quarter	-0.008***	-0.009***		0.008	-0.012**		-0.006**	-0.011***	
	(0.003)	(0.003)		(0.005)	(0.005)		(0.003)	(0.003)	
School-age children x 4th quarter	-0.010*	-0.008		-0.001	-0.017*		-0.008*	-0.011**	
	(0.005)	(0.005)		(0.009)	(0.009)		(0.005)	(0.004)	
First-time buyer			0.000			-0.003			-0.003
			(0.002)			(0.004)			(0.002)
Out-of-town buyer			0.017***			0.004			0.014***
			(0.002)			(0.003)			(0.002)
Assessed value (log)		0.575***			0.519***			0.561***	
		(0.012)			(0.010)			(0.008)	
Constant		3.007***			3.504***			3.147***	
		(0.079)			(0.068)			(0.055)	
Additional controls:									
Property characteristics		No			No			No	
Location		No			No			No	
Property fixed effects		Yes			Yes			Yes	
Quarter fixed effects		Yes			Yes			Yes	
Year fixed effects		Yes			Yes			Yes	
Pseudo R2		0.700			0.844			0.735	
Number of observations		71,417			25,799			97,216	

Table C4: Gender differences when selling inherited properties (Appendix Table F3 with wealth control)

This table applies the negotiation model of Harding, Rosenthal, and Sirmans (2003) on our sample of inherited properties. We modify the model such that differences between seller (the beneficiary) and buyer characteristics capture negotiation effects and sums of owner (the deceased) and buyer characteristics capture demand effects. The dependent variable is the log of transaction price in thousands year-2015 DKK. Data covers estate sales due to deaths from 1994 to 2013. Columns (1), (3), and (5) have the coefficients to the differences, i.e., the negotiation effects. Columns (2), (4), and (6) have the coefficients to the sums, i.e., the demand effects. Columns (1)–(2) contain only houses; (3)–4), only apartments; and (5)–(6), both houses and apartments. Additional controls include: quarter fixed-effects, and year fixed-effects. Robust standard errors are reported in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

	Houses		Apartments		All	
	Negotiation	Demand	Negotiation	Demand	Negotiation	Demand
	(1)	(2)	(3)	(4)	(5)	(6)
Single female	-0.005	0.019***	0.021	0.042***	-0.004	0.019***
	(0.008)	(0.005)	(0.017)	(0.013)	(0.008)	(0.005)
Single female x apartment					0.023	0.022
					(0.020)	(0.014)
Couple	0.024***	0.070***	0.011	0.030	0.023***	0.072***
	(0.007)	(0.007)	(0.019)	(0.023)	(0.007)	(0.007)
Couple x apartment					-0.009	-0.036
					(0.019)	(0.023)
Age	0.003***	0.001***	0.002***	0.001**	0.002***	0.001***
	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)
Income	-0.014*	0.010***	0.001	-0.002	-0.013*	0.009***
	(0.007)	(0.003)	(0.014)	(0.007)	(0.007)	(0.003)
Net wealth	0.005***	-0.001**	-0.000	0.001*	0.004***	-0.000
	(0.002)	(0.000)	(0.003)	(0.001)	(0.001)	(0.000)
College	0.015**	0.023***	-0.008	0.046***	0.011**	0.026***
	(0.006)	(0.007)	(0.014)	(0.016)	(0.005)	(0.006)
Self-employed	0.065*	-0.005	0.077	0.215***	0.071**	0.029
	(0.036)	(0.040)	(0.069)	(0.072)	(0.033)	(0.038)
Children (dummy)	0.015***	0.001	0.030**	0.016	0.017***	0.003
	(0.006)	(0.008)	(0.015)	(0.021)	(0.006)	(0.008)
Apartment					0.085***	
					(0.023)	
Assessed value (log)	1.051***		0.949***		1.042***	
	(0.007)		(0.025)		(0.007)	
Constant	-0.464***		0.391**		-0.395***	
	(0.055)		(0.171)		(0.053)	
Additional controls:						
Property characteristics	No		No		No	
Location	No		No		No	
Property fixed effects	No		No		No	
Quarter fixed effects	Yes		Yes		Yes	
Year fixed effects	Yes		Yes		Yes	
Pseudo R2	0.832		0.836		0.830	
Number of observations	12,633		1,320		13,953	

Appendix D: Extra descriptive statistics

Table D1: Buyer and seller characteristics (repeated sales)

This table shows characteristics of buyers and sellers in 97,216 property transactions from 1994 to 2013, in which both buyers and sellers are between 18 and 65 years of age and did not experience a change in the composition of adult household members around the time of trade. Also, the property has been traded more than once during the period. Households consist of one or two adults living together and the number of children living with them. A household takes part in a transaction if at least one adult in the household buys or sells property. Buyers are identified as the owners of the property the year after the transaction, while sellers are identified as the owners of the property, registered the January 1, in the year of the transaction. We take household characteristics from December 31 in the year before the transaction year. *Age* is mean age of the adult household members. *Income* and *net wealth* are household totals in 2015-prices, winsorized at 1 percent in both ends, and presented in millions Danish kroner. *College* is the share of adult household members with a college degree. *Self-employed* is the share of adult household members that are self-employed. All shares take values 0, 0.5, or 1. *School-age children* is a dummy for having children between 5 and 15 years old (the children do not necessarily live in the household). *First-time buyer* indicates that no member of the household has previously owned real estate. Standard deviations are presented in parentheses for non-indicator variables. *t-statistics* are in brackets. *** indicates significance at the 1% level.

	Buyers				Sellers			
	All	Single women	Single men	Difference	All	Single women	Single men	Difference
Age	38.23	39.75	35.14	4.62***	41.57	46.54	40.83	5.71***
	(11.38)	(12.12)	(11.25)	[27.8]	(11.5)	(12.24)	(11.88)	[32.81]
Income (100,000 DKR)	3.68	3.44	3.61	-0.17***	3.74	3.41	3.81	-0.41***
	(2.04)	(1.95)	(2.12)	[-5.86]	(1.88)	(1.78)	(2.17)	[-14.02]
Net wealth (mil. DKR)	0.44	0.44	0.27	0.16***	0.48	0.62	0.40	0.22***
	(1.49)	(1.2)	(1.09)	[10.16]	(1.46)	(1.31)	(1.26)	[12.09]
College	0.27	0.34	0.20	0.14***	0.26	0.30	0.19	0.11***
				[22.1]				[17.61]
Self-employed	0.04	0.03	0.03	0.00	0.04	0.03	0.04	-0.01***
				[-1.48]				[-5.08]
School-age children	0.26	0.16	0.13	0.03***	0.32	0.15	0.18	-0.03***
				[5.78]				[-6.51]
First-time buyer	0.31	0.43	0.52	-0.10***				
				[-13.84]				
Out-of-town buyer	0.48	0.41	0.41	-0.01				
				[-0.83]				
N	97,216	8,806	11,119		97,216	9,082	10,107	

Table D2: Property characteristics (repeated sales)

This table shows characteristics of properties traded more than once during 1994-2013, separately for houses and apartments. *Price* is the realized sales price, and *assessed value* is the assessed value of the property from the Danish tax authorities prior to the sales. Both prices and assessed value are measured in thousand year-2015 DKK. *Interior size* and *Lot size* are measured in square meters. *House age* and *building age* are measured in years. *Rooms* and *bathrooms* are count variables. *Rural* indicates a rural area. Standard deviations are presented in parentheses for non-indicator variables. *t-statistics* are in brackets. *** and ** indicate significance at the 1% and 5% levels, respectively.

		Buyers			Sellers		
	All	Single women (1)	Single men (2)	Difference (1)–(2)	Single women (1)	Single men (2)	Difference (1)–(2)
A. Houses							
Number of transactions	71,417	4,371	5,122		5,608	5,933	
Price (1000 DKK)	1431.15	1185.69	1009.47	176.21***	1238.89	1117.85	121.04***
	(1007.31)	(928.7)	(815.5)	[9.84]	(1084.52)	(914.67)	[6.49]
Assessed value	1141.18	963.59	850.95	112.64***	1034.27	951.78	82.49***
	(768.38)	(695.9)	(632.44)	[8.26]	(797.57)	(726.21)	[5.81]
Interior size (m^2)	114.46	96.84	95.22	1.62**	107.10	104.65	2.45***
	(44.53)	(35.4)	(35.8)	[2.21]	(43.98)	(43.93)	[3]
Lot size (m^2)	983.41	774.47	901.78	-127.31***	969.81	1010.33	-40.52
	(1260.81)	(1545.47)	(817.29)	[-5.12]	(1937.85)	(1144.19)	[-1.38]
House age (years)	43.36	52.01	52.64	-0.63	49.36	49.73	-0.38
	(33.75)	(39.52)	(39.55)	[-0.78]	(36.65)	(38)	[-0.54]
Rooms (#)	4.28	3.75	3.71	0.04*	4.07	3.99	0.07***
	(1.26)	(1.07)	(1.14)	[1.76]	(1.27)	(1.27)	[3.15]
Bathrooms (#)	1.34	1.17	1.14	0.03***	1.27	1.23	0.04***
	(0.54)	(0.44)	(0.41)	[3.82]	(0.52)	(0.5)	[3.71]
Rural	0.34	0.33	0.42	-0.10***	0.37	0.42	-0.05***
				[-9.58]			[-5.45]
B. Apartments							
Number of transactions	25,799	4,435	5,997		3,474	4,174	
Price (1000 DKK)	1288.11	1166.02	1065.03	100.98***	1164.61	1078.96	85.65***
	(817.16)	(705.53)	(659.09)	[7.51]	(703.48)	(668.7)	[5.45]
Assessed value	1040.41	939.38	861.35	78.03***	942.75	866.01	76.74***
	(688.6)	(625.65)	(539.89)	[6.82]	(611.08)	(555.22)	[5.75]
Interior size (m^2)	74.59	70.19	67.91	2.28***	68.78	66.38	2.40***
	(27.42)	(23.06)	(21.98)	[5.13]	(24.36)	(24.34)	[4.29]
Building age (years)	66.37	65.33	64.27	1.06	66.58	65.50	1.08
	(35.67)	(35.48)	(34.95)	[1.52]	(35.89)	(35.92)	[1.31]
Rooms (#)	2.63	2.46	2.36	0.11***	2.41	2.30	0.11***
	(1.03)	(0.88)	(0.87)	[6.3]	(0.94)	(0.93)	[5.01]
Bathrooms (#)	1.03	1.02	1.01	0.01**	1.02	1.01	0.01
	(0.22)	(0.17)	(0.15)	[2.28]	(0.18)	(0.18)	[1.45]
Rural	0.01	0.00	0.01	0.00**	0.01	0.01	0.00
				[-1.97]			[-0.62]

Table D3: Identifying differences in seller and buyer characteristics

This table shows the frequencies for seller-buyer differences in indicator variables in the samples. *Single female* indicates a household consisting of one adult female. *Apartment* indicates that the traded property is an apartment. *College* is the share of adult household members with a college degree. *Self-employed* is the share of adult household members that are self-employed. *School-age children* is a dummy for having children between 5 and 15 years old. Percentages are presented in parentheses.

	Full Sample					Repeat Sample				
Seller – buyer	-1	-0.5	0	0.5	1	-1	-0.5	0	0.5	1
Single female	24,607	-	282,184	-	30,894	7,513	-	81,914	-	7,789
	(7.3)		(83.6)		(9.1)	(7.7)		(84.3)		(8.0)
Apartment * single female	10,351	-	319,823	-	7,511	3,681	-	90,815	-	2,720
	(3,1)		(94.7)		(2.2)	(3.8)		(93.4)		(2.8)
Couple	51,629	-	240,895	-	45,161	13,167	-	70,146	-	13,903
	(15.3)		(71.3)		(13.4)	(13.5)		(72.2)		(14.3)
Apartment * couple	10,867	-	307,693	-	19,125	4,028	-	86,376	-	6,812
	(3.2)		(91.1)		(5.7)	(4.1)		(88.8)		(7.0)
College	62,988	-	205,734	-	68,963	15,765	-	60,127	-	21,324
	(18.7)		(60.9)		(20.4)	(16.2)		(61.8)		(21.9)
Self-employed	2,693	18,820	292,520	20,443	3,209	827	5,685	83,793	5,954	957
	(0.8)	(5.6)	(86.6)	(6.1)	(1.0)	(0.9)	(5.8)	(86.2)	(6.1)	(1.0)
School-age children	7,698	22,958	253,184	32,081	21,764	2,070	6,773	75,424	8,273	4,676
	(2.3)	(6.8)	(75.0)	(9.5)	(6.4)	(2.1)	(7.0)	(77.6)	(8.5)	(4.8)
N			337,685					97,216		

Table D4: Buyer and seller combinations

The table shows the frequencies of all buyer-seller combinations. Panel A has buyer-seller combinations for the full sample used in Table 1 to Table 5. Panel B has buyer-seller combinations for the repeat sales sample in Table 6.

(A) Full Sample

Seller\buyer	Couple	Single male	Single female	Total
Couple	221,104	24,704	20,457	266,265
Single male	25,803	6,460	4,150	36,413
Single female	25,826	5,068	4,113	35,007
Total	272,733	36,232	28,720	337,685

(B) Repeat sales samples

Seller\buyer	Couple	Single male	Single female	Total
Couple	64,124	7,662	6,241	78,027
Single male	6,872	1,963	1,272	10,107
Single female	6,295	1,494	1,293	9,082
Total	77,291	11,119	8,806	97,216

Table D5: Individuals characteristics, by relationship status

This table shows average characteristics of individual buyers and sellers, separate for single individuals and individuals in couples. Buyer and seller data cover all property transactions in which both buyers and sellers are between 18 and 65 years of age and did not experience a change in the composition of adult household members around the time of transaction. *Income* and *net wealth* are in 2015 prices, winsorized at 1 percent in both ends, and presented in millions Danish kroner. *College* is a dummy for having a college degree and *Self-employed* a dummy for being self-employed. *School-age children* is a dummy for having children between 5 and 15 years old (the children do not necessarily live in the household). Standard deviations are presented in parentheses for non-indicator variables. *t-statistics* are in brackets. *** indicates significance at the 1% level.

	Buyers and sellers			Buyers			Sellers		
	Individuals in couples	Singles	Difference	Individuals in a couple	Singles	Difference	Individuals in a couple	Singles	Difference
A. Women									
Age	38.99	46.04	-7.05***	37,04	41,86	-4,82***	40,95	49,46	-8,51***
	(11.55)	(12.51)	[143.74]	(11,13)	(12,21)	[68,78]	(11,64)	(11,69)	[128,12]
Income	0.29	0.34	-0.06***	0,28	0,35	-0,07***	0,29	0,34	-0,05***
	(0.14)	(0.19)	[91.13]	(0,14)	(0,2)	[72,93]	(0,14)	(0,18)	[56,14]
Net wealth	0.15	0.64	-0.49***	0,12	0,48	-0,36***	0,18	0,78	-0,60***
.	(0.60)	(1.18)	[168.86]	(0,57)	(1,08)	[89,41]	(0,64)	(1,23)	[142,14]
College	0.27	0.31	-0.03***	0,29	0,34	-0,06***	0,26	0,27	-0,01***
			[16.90]			[20,04]			[5,53]
Self-employed	0.02	0.03	-0.01***	0,02	0,03	-0,01***	0,02	0,03	-0,01***
			[18.06]			[15,68]			[9,99]
School-age children	0.29	0.15	0.13***	0,27	0,18	0,10***	0,30	0,14	0,16***
			[-70.30]			[-35,86]			[-62,94]
N	501,374	63,727		252,007	28,720		249,367	35,007	
B. Men									
Age	41.17	40.07	1.11***	39,15	36,66	2,49***	43,21	43,46	-0,24***
	(11.88)	(12.38)	[-23.36]	(11,46)	(11,62)	[-38,64]	(11,94)	(12,19)	[3,6]
Income	0.42	0.37	0.05***	0,41	0,37	0,04***	0,43	0,38	0,05***
	(0.22)	(0.22)	[-53.58]	(0,22)	(0,22)	[-33,78]	(0,22)	(0,22)	[-42,16]
Net wealth	0.34	0.42	-0.08***	0,3	0,3	0,0***	0,4	0,5	-0,1***
	(0.96)	(1.09)	[21.34]	(0,94)	(0,96)	[5,54]	(0,99)	(1,19)	[23,84]
College	0.25	0.19	0.06***	0,27	0,20	0,06***	0,24	0,18	0,05***
			[-33.53]			[-24,77]			[-22,59]
Self-employed	0.05	0.04	0.02***	0,05	0,03	0,02***	0,06	0,04	0,01***
			[-17.86]			[-13,88]			[-11,53]
School-age children	0.28	0.16	0.12***	0,27	0,14	0,13***	0,29	0,19	0,11***
			[-67.91]			[-53,51]			[-42,83]
N	501,954	72,645		252,140	36,232		249,814	36,413	

Table D6: Individuals characteristics, by relationship status, under 40

This table shows average characteristics of individual buyers and sellers, separate for single individuals and individuals in couples. Buyer and seller data cover all property transactions in which both buyers and sellers are between 18 and 40 years of age and did not experience a change in the composition of adult household members around the time of transaction. *Income* and *net wealth* are in 2015 prices, winsorized at 1 percent in both ends, and presented in millions Danish kroner. *College* is a dummy for having a college degree and *Self-employed* a dummy for being self-employed. *School-age children* is a dummy for having children between 5 and 15 years old (the children do not necessarily live in the household). Standard deviations are presented in parentheses for non-indicator variables. *t-statistics* are in brackets. *** indicates significance at the 1% level.

	Buyers and sellers			Buyers			Sellers		
	Individuals in couples	Singles	Difference	Individuals in a couple	Singles	Difference	Individuals in a couple	Singles	Difference
A. Women									
Age	30.41	31.21	-0.80***	29,70	30,47	-0,77***	31,27	32,36	-1,09***
	(5.29)	(5.60)	[21.36]	(5,38)	(5,69)	[15,66]	(5,05)	(5,25)	[19,16]
Income	0.27	0.32	-0.04***	0,26	0,31	-0,04***	0,29	0,33	-0,04***
	(0.12)	(0.16)	[45.85]	(0,12)	(0,15)	[38,35]	(0,12)	(0,16)	[28,26]
Net wealth	0.03	0.19	-0.16***	0,02	0,14	-0,13***	0,04	0,26	-0,21***
	(0.38)	(0.66)	[55.07]	(0,34)	(0,56)	[38,44]	(0,43)	(0,79)	[41,43]
College	0.28	0.29	-0.02***	0,27	0,30	-0,03***	0,28	0,27	0,00
			[5.09]			[6,99]			[-0,54]
Self-employed	0.01	0.02	-0.01***	0,01	0,02	-0,01***	0,01	0,02	-0,01***
			[12.36]			[10,25]			[7,58]
School-age children	0.36	0.24	0.12***	0,31	0,20	0,10***	0,42	0,29	0,13***
			[-36.00]			[-25,09]			[-23,58]
N	289,778	21,581		159,684	13,171		130,094	8,410	
B. Men									
Age	31.46	30.34	1.12***	30,79	29,44	1,35***	32,30	31,69	0,61***
	(4.90)	(5.32)	[-42.07]	(5,01)	(5,3)	[-38,47]	(4,62)	(5,06)	[-15,6]
Income	0.38	0.35	0.04***	0,36	0,34	0,03***	0,41	0,36	0,05***
	(0.18)	(0.17)	[-39.53]	(0,18)	(0,17)	[-23,83]	(0,19)	(0,18)	[-30,63]
Net wealth	0.05	0.15	-0.10***	0,02	0,12	-0,09***	0,08	0,19	-0,12***
	(0.52)	(0.64)	[34.51]	(0,47)	(0,53)	[27,81]	(0,58)	(0,77)	[22,64]
College	0.24	0.16	0.07***	0,24	0,18	0,07***	0,23	0,15	0,08***
			[-31.93]			[-22,35]			[-23,55]
Self-employed	0.03	0.02	0.00***	0,02	0,02	0,00***	0,03	0,03	0,00***
			[-4.48]			[-3,12]			[-2,64]
School-age children	0.32	0.14	0.18***	0,27	0,10	0,17***	0,38	0,19	0,19***
			[-75.46]			[-57,64]			[-47,21]
N	264,270	39,898		147,538	23,904		116,732	15,994	

Appendix E: Hedonic model without demand effects
Table E1: Hedonic model without demand effects

This table shows gender differences in sales prices by buyer and seller characteristics using a simple hedonic regression. The dependent variable is the log of transaction price in thousand year-2015 DKK. Data covers property transactions from 1994 to 2013, in which both the buyer and seller are stable households with a member between 18 and 65 years of age. Columns (1–3), (6–8), and (11–13) have all sales, while columns (4–5), (9–10), and (15–15) only look at properties that are traded twice within the period (resales). Columns (1)–(5) contain only houses; (6)–(10), only apartments; and (11)–(15), both houses and apartments. Additional controls include *couple buyer* and *couple seller*, buyer and seller characteristics, property characteristics, location indicators, quarter fixed effects, and year fixed effects. Only coefficients on the variable of interest, female buyers and female sellers, are reported. Robust standard errors are reported in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively. The linear test of whether female buyers and sellers trade at the same price is reported in the bottom of the table as p-values of the test.

	Houses				Apartments				All			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Specification	Baseline	+ Assessed Value	Baseline	+ Fixed Effects	Baseline	+ Assessed Value	Baseline	+ Fixed Effects	Baseline	+ Assessed Value	Baseline	+ Fixed Effects
Sample	Full	Full	Repeat sales	Repeat sales	Full	Full	Repeat sales	Repeat sales	Full	Full	Repeat sales	Repeat sales
Single female buyer	0.110***	0.063***	0.058***	0.040***	0.075***	0.027***	0.023***	0.007	0.110***	0.063***	0.058***	0.035***
	(0.005)	(0.003)	(0.005)	(0.007)	(0.004)	(0.002)	(0.004)	(0.004)	(0.005)	(0.003)	(0.005)	(0.006)
Single female seller	0.070***	0.044***	0.042***	0.038***	0.071***	0.025***	0.021***	0.016***	0.069***	0.043***	0.042***	0.035***
	(0.004)	(0.003)	(0.005)	(0.006)	(0.005)	(0.003)	(0.005)	(0.005)	(0.004)	(0.003)	(0.005)	(0.006)
Single female buyer x apartment									-0.016**	-0.033***	-0.032***	-0.025***
									(0.006)	(0.004)	(0.007)	(0.008)
Single female seller x apartment									0.011	-0.019***	-0.024***	-0.019**
Additional controls												
Buyer and seller characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Assessed value	No	Yes	Yes	Yes	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Property characteristics	Yes	Yes	Yes	No	Yes	Yes	Yes	No	Yes	Yes	Yes	No
Location	Yes	Yes	Yes	No	Yes	Yes	Yes	No	Yes	Yes	Yes	No
Property fixed effects	No	No	No	Yes	No	No	No	Yes	No	No	No	Yes
Quarter fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Pseudo R2	0.626	0.869	0.873	0.700	0.678	0.891	0.895	0.843	0.611	0.871	0.875	0.735
Number of observations	269,350	269,350	71,417	71,417	68,335	68,335	25,799	25,799	337,685	337,685	97,216	97,216
P-values for test of *Single female buyer* = *Single female seller*	0.000	0.000	0.041	0.850	0.500	0.570	0.748	0.142	0.000	0.000	0.038	0.998

Appendix F: Robustness analyses

Table F1: Gender differences in negotiation controlling for assessed value and ownership length

This table shows gender differences in negotiation and demand using the estimation methodology of Harding, Rosenthal, and Sirmans (2003), adding controls for the tax-assessed value of the property and the ownership length, measured in years from acquisition date to sales date. The dependent variable is the log of transaction price in thousand year-2015 DKK. Data covers property transactions from 1994 to 2013, in which both the buyer and seller are stable households with a member between 18 and 65 years of age. Columns (1), (4), and (7) have the coefficients to the differences, i.e., the negotiation effects. Columns (2), (5), and (8) have the coefficients to the sums, i.e., the demand effects. Columns (1)–(3) contain only houses; (4)–(6), only apartments; and (7)–(9), both houses and apartments. Additional controls include: buyer and seller characteristics, property characteristics, location indicators, quarter fixed effects, and year fixed effects. Robust standard errors are reported in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

	Houses			Apartments			All		
	Bargaining (1)	Demand (2)	Other controls (3)	Bargaining (4)	Demand (5)	Other controls (6)	Bargaining (7)	Demand (8)	Other controls (9)
Single female	-0.011***	0.052***		-0.005**	0.022***		-0.012***	0.051***	
	(0.002)	(0.002)		(0.002)	(0.002)		(0.002)	(0.002)	
Single female x apartment							0.005*	-0.028***	
							(0.003)	(0.003)	
Couple	0.006***	0.073***		-0.001	0.003*		0.003**	0.075***	
	(0.002)	(0.002)		(0.002)	(0.002)		(0.002)	(0.002)	
Couple x apartment							0.001	-0.078***	
							(0.002)	(0.002)	
Ownership length			-0.003***			-0.007***			-0.004***
			(0.000)			(0.000)			(0.000)
Ownership length x apartment									-0.003***
									(0.001)
Ownership length x female seller			0.002***			0.004***			0.002***
			(0.000)			(0.001)			(0.000)
Ownership length x female seller x apartment									0.002***
									(0.001)
Ownership length x couple seller			0.002***			0.002***			0.002***
			(0.000)			(0.000)			(0.000)
Ownership length x couple seller x apartment									0.001*
									(0.001)
Apartment									0.099***
									(0.004)
Assessed value (log)			0.917***			0.882***			0.913***
			(0.003)			(0.004)			(0.002)
Constant			0.632***			0.933***			0.662***
			(0.003)			(0.005)			(0.002)
Additional controls:									
Buyer and seller characteristics		Yes			Yes			Yes	
Property characteristics		Yes			Yes			Yes	
Location		Yes			Yes			Yes	
Property fixed effects		No			No			No	
Quarter fixed effects		Yes			Yes			Yes	
Year fixed effects		Yes			Yes			Yes	
Pseudo R2		0.869			0.892			0.871	
Number of observations		269,350			68,335			337,685	

Table F2: Repeated sales without property fixed effects

This table presents results from a HRS model within a repeated sales sample, controlling for tax-assessed value, but not controlling for property fixed effects. The dependent variable is the log of transaction price in thousand year-2015 DKK. Data covers property transactions from 1994 to 2013, in which both the buyer and seller are stable households with a member between 18 and 65 years of age, and the property is traded more than once during the time period. Columns (1), (4), and (7) have the coefficients to the differences, i.e., the negotiation effects. Columns (2), (5), and (8) have the coefficients to the sums, i.e., the demand effects. Columns (1)–(3) contains only houses; (4)–(6), only apartments; and (7)–(9), both houses and apartments. Additional controls include: property characteristics, location indicators, quarter fixed effects, and year fixed effects. Robust standard errors are reported in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels.

		Houses			**Apartments**			**All**	
	Bargaining	Demand	Other controls	Bargaining	Demand	Other controls	Bargaining	Demand	Other controls
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Single female	-0.008**	0.050***		-0.001	0.022***		-0.008**	0.050***	
	(0.004)	(0.004)		(0.003)	(0.003)		(0.004)	(0.004)	
Single female x apartment							0.004	-0.028***	
							(0.005)	(0.005)	
Couple	0.015***	0.069***		0.001	0.004		0.012***	0.071***	
	(0.003)	(0.003)		(0.003)	(0.003)		(0.003)	(0.003)	
Couple x apartment							-0.008*	-0.072***	
							(0.004)	(0.004)	
Age	0.000	-0.001***		-0.000***	-0.001***		0.000	-0.001***	
	(0.000)	(0.000)		(0.000)	(0.000)		(0.000)	(0.000)	
Income	-0.017***	0.076***		0.012***	0.039***		-0.003	0.063***	
	(0.002)	(0.002)		(0.003)	(0.003)		(0.002)	(0.002)	
College	-0.011***	0.022***		-0.008***	0.025***		-0.012***	0.023***	
	(0.002)	(0.002)		(0.002)	(0.002)		(0.001)	(0.001)	
Self-employed	-0.005	0.018***		-0.008	-0.012**		-0.005	0.009**	
	(0.004)	(0.004)		(0.006)	(0.006)		(0.003)	(0.003)	
School-age children x 1st quarter	-0.002	-0.016***		0.005	-0.029***		-0.001	-0.016***	
	(0.002)	(0.002)		(0.005)	(0.005)		(0.002)	(0.002)	
School-age children x 2nd quarter	-0.005**	-0.017***		0.001	-0.020***		-0.004*	-0.018***	
	(0.002)	(0.002)		(0.004)	(0.004)		(0.002)	(0.002)	
School-age children x 3rd quarter	-0.001	-0.021***		0.009*	-0.025***		0.001	-0.021***	
	(0.003)	(0.003)		(0.005)	(0.005)		(0.002)	(0.002)	
School-age children x 4th quarter	-0.004	-0.010**		0.010	-0.028***		-0.001	-0.014***	
	(0.005)	(0.004)		(0.009)	(0.008)		(0.004)	(0.004)	
First-time buyer			-0.010***			-0.003			-0.009***
			(0.002)			(0.003)			(0.002)
Out-of-town buyer			0.018***			0.015***			0.018***
			(0.002)			(0.003)			(0.002)
Apartment									0.087***
									(0.007)
Assessed value (log)			0.908***			0.874***			0.904***
			(0.004)			(0.006)			(0.003)
Constant			0.706***			1.014***			0.750***
			(0.028)			(0.035)			(0.021)
Additional controls:									
Property characteristics		Yes			Yes			Yes	
Location		Yes			Yes			Yes	
Property fixed effects		No			No			No	
Quarter fixed effects		Yes			Yes			Yes	
Year fixed effects		Yes			Yes			Yes	
Pseudo R2		0.873			0.895			0.875	
Number of observations		71,417			25,799			97,216	

Table F3: Repeated sales without property fixed effects by number of transactions

This table corresponds to Table F2. Column (1) to (3) repeat column (7) to (9) in Table 5 and show all repeat sales. Columns (4)-(6) and (7)-(9) show properties sold only twice during the sample period separately from properties sold more than twice.

	All repeat sales			Two sales			Three or more sales		
	Negotiation (1)	Demand (2)	Other controls (3)	Negotiation (4)	Demand (5)	Other controls (6)	Negotiation (7)	Demand (8)	Other controls (9)
Single female	-0.008**	0.050***		-0.008*	0.049***		-0.009	0.055***	
	(0.004)	(0.004)		(0.004)	(0.004)		(0.010)	(0.010)	
Single female x apartment	0.004	-0.028***		0.005	-0.028***		0.002	-0.030**	
	(0.005)	(0.005)		(0.005)	(0.005)		(0.012)	(0.012)	
Couple	0.012***	0.071***		0.010***	0.071***		0.021***	0.071***	
	(0.003)	(0.003)		(0.003)	(0.003)		(0.008)	(0.008)	
Couple x apartment	-0.008*	-0.072***		-0.004	-0.072***		-0.024**	-0.072***	
	(0.004)	(0.004)		(0.004)	(0.004)		(0.010)	(0.009)	
Age	0.000	-0.001***		0.000	-0.001***		0.000	-0.001***	
	(0.000)	(0.000)		(0.000)	(0.000)		(0.000)	(0.000)	
Income	-0.003	0.063***		-0.004**	0.064***		0.000	0.058***	
	(0.002)	(0.002)		(0.002)	(0.002)		(0.005)	(0.004)	
College	-0.012***	0.023***		-0.012***	0.024***		-0.010***	0.021***	
	(0.001)	(0.001)		(0.002)	(0.001)		(0.003)	(0.003)	
Self-employed	-0.005	0.009**		-0.005	0.007*		-0.005	0.014*	
	(0.003)	(0.003)		(0.004)	(0.004)		(0.008)	(0.008)	
School-age children x 1st quarter	-0.001	-0.016***		0.000	-0.015***		-0.005	-0.021***	
	(0.002)	(0.002)		(0.002)	(0.002)		(0.005)	(0.005)	
School-age children x 2nd quarter	-0.004*	-0.018***		-0.004*	-0.018***		-0.002	-0.016***	
	(0.002)	(0.002)		(0.002)	(0.002)		(0.005)	(0.005)	
School-age children x 3rd quarter	0.001	-0.021***		0.003	-0.019***		-0.005	-0.030***	
	(0.002)	(0.002)		(0.003)	(0.002)		(0.006)	(0.006)	
School-age children x 4th quarter	-0.001	-0.014***		-0.002	-0.013***		0.005	-0.018**	
	(0.004)	(0.004)		(0.005)	(0.004)		(0.010)	(0.009)	
First-time buyer			-0.009***			-0.009***			-0.008*
			(0.002)			(0.002)			(0.004)
Out-of-town buyer			0.018***			0.019***			0.015***
			(0.002)			(0.002)			(0.004)
Assessed value (log)			0.904***			0.905***			0.893***
			(0.003)			(0.003)			(0.008)
Constant			0.750***			0.742***			0.804***
			(0.021)			(0.023)			(0.056)
Additional controls:									
Property characteristics		Yes			Yes			Yes	
Location		Yes			Yes			Yes	
Property fixed effects		No			No			No	
Quarter fixed effects		Yes			Yes			Yes	
Year fixed effects		Yes			Yes			Yes	
Pseudo R2		0.875			0.875			0.872	
Number of observations		97,216			80,480			16,736	

Table F4: Repeated sales with property fixed effects by number of transactions

This table corresponds to Table 6. Column (1) to (3) repeat column (7) to (9) in Table 5 and show all repeat sales. Columns (4)-(6) and (7)-(9) show properties sold only twice during the sample period separately from properties sold more than twice.

	All repeat sales			Two sales			Three or more sales		
	Negotiation	Demand	Other controls	Negotiation	Demand	Other controls	Negotiation	Demand	Other controls
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Single female	-0.000	0.035***		-0.000	0.035***		0.002	0.035***	
	(0.004)	(0.005)		(0.004)	(0.005)		(0.009)	(0.012)	
Single female x apartment	0.003	-0.022***		0.005	-0.024***		-0.003	-0.016	
	(0.005)	(0.006)		(0.006)	(0.007)		(0.011)	(0.014)	
Couple	0.026***	0.058***		0.025***	0.058***		0.031***	0.058***	
	(0.003)	(0.004)		(0.004)	(0.004)		(0.007)	(0.008)	
Couple x apartment	-0.019***	-0.061***		-0.018***	-0.061***		-0.027***	-0.061***	
	(0.004)	(0.005)		(0.005)	(0.005)		(0.008)	(0.011)	
Age	-0.000***	-0.001***		-0.000***	-0.001***		-0.000	-0.001***	
	(0.000)	(0.000)		(0.000)	(0.000)		(0.000)	(0.000)	
Income	-0.011***	0.031***		-0.012***	0.032***		-0.008*	0.027***	
	(0.002)	(0.002)		(0.002)	(0.002)		(0.004)	(0.005)	
College	-0.011***	0.009***		-0.011***	0.011***		-0.011***	0.006	
	(0.001)	(0.002)		(0.002)	(0.002)		(0.003)	(0.004)	
Self-employed	0.001	0.007*		0.003	0.006		-0.007	0.011	
	(0.004)	(0.004)		(0.004)	(0.005)		(0.007)	(0.009)	
School-age children x 1st quarter	-0.005**	-0.011***		-0.005*	-0.011***		-0.004	-0.010*	
	(0.002)	(0.002)		(0.003)	(0.003)		(0.005)	(0.005)	
School-age children x 2nd quarter	-0.007***	-0.008***		-0.007***	-0.009***		-0.007	-0.005	
	(0.002)	(0.002)		(0.002)	(0.002)		(0.005)	(0.005)	
School-age children x 3rd quarter	-0.005*	-0.011***		-0.005*	-0.011***		-0.005	-0.008	
	(0.003)	(0.003)		(0.003)	(0.003)		(0.006)	(0.006)	
School-age children x 4th quarter	-0.008*	-0.011**		-0.008	-0.012**		-0.007	-0.007	
	(0.005)	(0.004)		(0.005)	(0.005)		(0.010)	(0.009)	
First-time buyer			-0.003			-0.003			-0.004
			(0.002)			(0.002)			(0.005)
Out-of-town buyer			0.014***			0.014***			0.012***
			(0.002)			(0.002)			(0.004)
Assessed value (log)			0.558***			0.557***			0.562***
			(0.008)			(0.009)			(0.018)
Constant			3.175***			3.184***			3.143***
			(0.054)			(0.061)			(0.119)
Additional controls:									
Property characteristics		No			No			No	
Location		No			No			No	
Property fixed effects		Yes			Yes			Yes	
Quarter fixed effects		Yes			Yes			Yes	
Year fixed effects		Yes			Yes			Yes	
Pseudo R2		0.735			0.731			0.750	
Number of observations		97,216			80,480			16,736	

Table F5: Gender differences when selling inherited properties

This table applies the negotiation model of Harding, Rosenthal, and Sirmans (2003) on our sample of inherited properties. We modify the model such that differences between seller (the beneficiary) and buyer characteristics capture negotiation effects and sums of owner (the deceased) and buyer characteristics capture demand effects. The dependent variable is the log of transaction price in thousands year-2015 DKK. Data covers estate sales due to deaths from 1994 to 2013. Columns (1), (4), and (7) have the coefficients on the differences, i.e., the negotiation effects. Columns (2), (5), and (8) have the coefficients on the sums, i.e., the demand effects. Columns (1)–(2) contain only houses; (3)–(4), only apartments; and (5)–(6), both houses and apartments. Additional controls include: Property characteristics, quarter fixed effects, and year fixed effects. Robust standard errors are reported in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

	Houses			**Apartments**			**All**		
	Negotiation	Demand	Other controls	Negotiation	Demand	Other controls	Negotiation	Demand	Other controls
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Single female	-0.002	0.017***		0.024	0.043***		-0.002	0.018***	
	(0.008)	(0.005)		(0.017)	(0.013)		(0.008)	(0.005)	
Single female x apartment							0.025	0.029**	
							(0.020)	(0.014)	
Couple	0.024***	0.072***		0.013	0.031		0.024***	0.073***	
	(0.007)	(0.007)		(0.019)	(0.024)		(0.007)	(0.007)	
Couple x apartment							-0.007	-0.030	
							(0.019)	(0.023)	
Age	0.002***	0.001***		0.002***	0.001***		0.002***	0.001***	
	(0.000)	(0.000)		(0.001)	(0.001)		(0.000)	(0.000)	
Income	-0.015**	0.009***		0.006	0.005		-0.013**	0.009***	
	(0.007)	(0.003)		(0.014)	(0.005)		(0.007)	(0.002)	
College	0.015**	0.028***		-0.010	0.041***		0.011**	0.030***	
	(0.006)	(0.007)		(0.014)	(0.015)		(0.005)	(0.006)	
Self-employed	0.077**	0.014		0.111*	0.226***		0.082**	0.045	
	(0.037)	(0.040)		(0.066)	(0.077)		(0.034)	(0.038)	
School-age children x 1st quarter	0.009	0.001		0.021	-0.003		0.011	0.003	
	(0.012)	(0.016)		(0.024)	(0.033)		(0.011)	(0.015)	
School-age children x 2nd quarter	0.024**	0.025**		0.044	0.027		0.026***	0.026**	
	(0.009)	(0.012)		(0.031)	(0.051)		(0.009)	(0.012)	
School-age children x 3rd quarter	0.013	0.008		0.014	-0.000		0.014	0.008	
	(0.011)	(0.017)		(0.025)	(0.034)		(0.011)	(0.016)	
School-age children x 4th quarter	0.009	-0.013		0.035	0.034		0.013	-0.010	
	(0.011)	(0.016)		(0.029)	(0.039)		(0.011)	(0.015)	
First-time buyer			0.004			-0.005			0.003
			(0.005)			(0.015)			(0.005)
Out-of-town buyer			0.017***			0.034**			0.019***
			(0.006)			(0.015)			(0.005)
Assessed value (log)			1.010***			0.943***			1.002***
			(0.008)			(0.030)			(0.008)
Constant			-0.041			0.391**			0.002
			(0.060)			(0.165)			(0.056)
Additional controls:									
Property characteristics		Yes			Yes			Yes	
Location		Yes			Yes			Yes	
Property fixed effects		No			No			No	
Quarter fixed effects		Yes			Yes			Yes	
Year fixed effects		Yes			Yes			Yes	
Pseudo R2		0.837			0.838			0.835	
Number of observations		12,633			1,320			13,953	

Table F6: Housing Returns

This Table shows gender differences in returns to housing following Goldsmith-Pinkham & Shue (2019). The dependent variable is the average annual real return to housing, calculated as $r_{it} = (P_{it}/P_{is})^{1/(t-s)} - 1$, with P_{it} and P_{is} being real selling price and real purchase price, and *t* and *s* being selling and buying year. Data covers holding period of Danish properties, where both purchase and sale happens in the period 1994-2013 and where the owner household is unchanged in the entire holding period. Column (1) to (3) replicates Table 1 of Goldsmith-Pinkham & Shue (2019). Column (4) adds controls for household characteristics (age, income, education, self-employment, and children), Column (5) adds controls for property characteristics (interior size, lot size, number of rooms, number of bathrooms, building age, municipality size, and rural area), and Column (6) adds the tax-assessed value of the property (assesses value at purchase and the assessed average annual rate of return through the holding period). Standard errors are reported in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

	Annual returns to housing					
	(1)	(2)	(3)	(4)	(5)	(6)
Single female	-0.017***	-0.012***	-0.008***	-0.002*	0.000	0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Couple	-0.027***	-0.013***	-0.009***	-0.002***	-0.004***	-0.003***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Holding Length			-0.009***	-0.009***	-0.009***	-0.009***
			(0.000)	(0.000)	(0.000)	(0.000)
Additional controls:						
Location-time-month fixed effects	No	Yes	Yes	Yes	Yes	Yes
Household characteristics	No	No	No	Yes	Yes	Yes
Property characteristics	No	No	No	No	Yes	Yes
Assessed value	No	No	No	No	No	Yes
R2	0.004	0.262	0.289	0.294	0.305	0.343
Number of observations	275,523	275,523	275,523	275,523	275,523	275,523

Table F7: Gender differences in negotiation among young households

This table corresponds to Table 4, but is restricted to property transactions where both the buyer and seller are 40 years old or younger. Columns (1), (4), and (7) have the coefficients on the differences, i.e., the negotiation effects. Columns (2), (5), and (8) have the coefficients on the sums, i.e., the demand effects. Columns (3), (6), and (9) show characteristics that are specific to buyers. Columns (1)–(3) contain only houses; (4)–(6), only apartments; and (7)–(9), both houses and apartments. Additional controls include: property characteristics, location indicators, quarter fixed effects, and year fixed effects. Robust standard errors are reported in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

	Houses			Apartments			All		
	Negotiation	Demand	Other controls	Negotiation	Demand	Other controls	Negotiation	Demand	Other controls
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Single female	-0.016**	0.054***		-0.002	0.050***		-0.017***	0.048***	
	(0.007)	(0.007)		(0.005)	(0.005)		(0.007)	(0.007)	
Single female x apartment							0.008	-0.001	
							(0.009)	(0.009)	
Couple	-0.050***	0.108***		-0.033***	0.038***		-0.050***	0.106***	
	(0.005)	(0.004)		(0.005)	(0.004)		(0.005)	(0.004)	
Couple x apartment							-0.002	-0.020***	
							(0.007)	(0.006)	
Age	-0.000	0.001***		-0.000	0.000		0.000	0.001***	
	(0.000)	(0.000)		(0.000)	(0.000)		(0.000)	(0.000)	
Income	-0.083***	0.361***		0.010	0.208***		-0.064***	0.339***	
	(0.006)	(0.005)		(0.009)	(0.008)		(0.005)	(0.004)	
College	-0.025***	0.083***		-0.010**	0.119***		-0.020***	0.108***	
	(0.003)	(0.003)		(0.004)	(0.004)		(0.002)	(0.002)	
Self-employed	-0.001	0.021***		-0.018	0.009		-0.006	0.024***	
	(0.008)	(0.008)		(0.013)	(0.013)		(0.007)	(0.007)	
School-age children x 1st quarter	0.019***	-0.035***		0.031***	-0.070***		0.018***	-0.042***	
	(0.004)	(0.004)		(0.009)	(0.008)		(0.004)	(0.003)	
School-age children x 2nd quarter	0.026***	-0.038***		0.032***	-0.059***		0.022***	-0.047***	
	(0.004)	(0.003)		(0.009)	(0.008)		(0.003)	(0.003)	
School-age children x 3rd quarter	0.029***	-0.046***		0.059***	-0.087***		0.031***	-0.052***	
	(0.004)	(0.004)		(0.011)	(0.010)		(0.004)	(0.003)	
School-age children x 4th quarter	0.028***	-0.048***		0.077***	-0.130***		0.036***	-0.062***	
	(0.007)	(0.007)		(0.019)	(0.018)		(0.007)	(0.006)	
First-time buyer			-0.033***			-0.022***			-0.035***
			(0.003)			(0.005)			(0.003)
Out-of-town buyer			0.097***			0.078***			0.086***
			(0.003)			(0.004)			(0.002)
Apartment									0.036***
									(0.011)
Constant			6.152***			5.821***			6.072***
			(0.018)			(0.028)			(0.017)
Additional controls:									
Property characteristics		Yes			Yes			Yes	
Location		Yes			Yes			Yes	
Property fixed effects		No			No			No	
Quarter fixed effects		Yes			Yes			Yes	
Year fixed effects		Yes			Yes			Yes	
Pseudo R2		0.640			0.721			0.638	
Number of observations		71,600			23,767			95,367	

Table F8: Gender differences in negotiation controlling for assessed value among young households

This table corresponds to Table 5, but is restricted to property transactions where both the buyer and seller are 40 years old or younger. Columns (1), (4), and (7) have the coefficients on the differences, i.e., the negotiation effects. Columns (2), (5), and (8) have the coefficients on the sums, i.e., the demand effects. Columns (3), (6), and (9) show characteristics that are specific to buyers. Columns (1)–(3) contain only houses; (4)–(6), only apartments; and (7)–(9), both houses and apartments. Additional controls include: property characteristics, location indicators, quarter fixed effects, and year fixed effects. Robust standard errors are reported in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

	Houses			Apartments			All		
	Negotiation (1)	Demand (2)	Other controls (3)	Negotiation (4)	Demand (5)	Other controls (6)	Negotiation (7)	Demand (8)	Other controls (9)
Single female	-0.012***	0.025***		-0.002	0.021***		-0.012***	0.023***	
	(0.005)	(0.004)		(0.003)	(0.003)		(0.005)	(0.004)	
Single female x apartment							0.008	-0.003	
							(0.006)	(0.005)	
Couple	-0.006*	0.076***		-0.007***	0.011***		-0.005	0.076***	
	(0.003)	(0.003)		(0.003)	(0.003)		(0.003)	(0.003)	
Couple x apartment							-0.010**	-0.061***	
							(0.004)	(0.004)	
Age	-0.001***	-0.001***		-0.001***	-0.001***		-0.001***	-0.001***	
	(0.000)	(0.000)		(0.000)	(0.000)		(0.000)	(0.000)	
Income	-0.034***	0.114***		-0.001	0.057***		-0.025***	0.099***	
	(0.003)	(0.004)		(0.005)	(0.004)		(0.003)	(0.003)	
College	-0.011***	0.027***		-0.008***	0.029***		-0.011***	0.030***	
	(0.002)	(0.002)		(0.002)	(0.002)		(0.001)	(0.001)	
Self-employed	-0.004	0.009*		-0.018**	0.003		-0.007*	0.008*	
	(0.005)	(0.005)		(0.007)	(0.007)		(0.004)	(0.004)	
School-age children x 1st quarter	0.007***	-0.020***		0.012**	-0.025***		0.007***	-0.019***	
	(0.002)	(0.002)		(0.005)	(0.005)		(0.002)	(0.002)	
School-age children x 2nd quarter	0.008***	-0.018***		0.011**	-0.022***		0.007***	-0.019***	
	(0.002)	(0.002)		(0.005)	(0.005)		(0.002)	(0.002)	
School-age children x 3rd quarter	0.007***	-0.023***		0.014**	-0.028***		0.008***	-0.023***	
	(0.003)	(0.002)		(0.006)	(0.006)		(0.002)	(0.002)	
School-age children x 4th quarter	0.005	-0.028***		0.025**	-0.053***		0.008*	-0.031***	
	(0.005)	(0.005)		(0.011)	(0.010)		(0.004)	(0.004)	
First-time buyer			-0.009***			-0.000			-0.009***
			(0.002)			(0.003)			(0.002)
Out-of-town buyer			0.020***			0.017***			0.020***
			(0.002)			(0.003)			(0.001)
Apartment									0.063***
									(0.007)
Assessed value (log)			0.835***			0.882***			0.847***
			(0.010)			(0.006)			(0.007)
Constant			1.143***			0.998***			1.105***
			(0.059)			(0.037)			(0.042)
Additional controls:									
Property characteristics		Yes			Yes			Yes	
Location		Yes			Yes			Yes	
Property fixed effects		No			No			No	
Quarter fixed effects		Yes			Yes			Yes	
Year fixed effects		Yes			Yes			Yes	
Pseudo R2		0.857			0.904			0.867	
Number of observations		71,600			23,767			95,367	

Table F9: Repeated sales among young households

This table corresponds to Table 6 within a repeated sales sample of buyers and sellers below 40. Columns (1), (4), and (7) have the coefficients to the differences, i.e. the bargaining effects. Columns (2), (5), and (8) have the coefficients to the sums, i.e. the demand effects. Columns (1)-(3) contains only houses, Columns (4)-(6) only apartments and (7)-(9) both houses and apartments. Additional controls include: quarter fixed-effects and year fixed-effects. Robust standard errors are reported in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

	Houses			**Apartments**			**All**		
	Bargaining (1)	Demand (2)	Buyers only (3)	Bargaining (4)	Demand (5)	Buyers only (6)	Bargaining (7)	Demand (8)	Buyers only (9)
Single female	-0.006	0.019		-0.007	-0.006		-0.004	0.012	
	(0.011)	(0.013)		(0.007)	(0.009)		(0.011)	(0.013)	
Single female x apartment							-0.003	-0.019	
							(0.013)	(0.016)	
Couple	0.018***	0.042***		0.002	-0.013*		0.019***	0.040***	
	(0.007)	(0.008)		(0.006)	(0.007)		(0.007)	(0.008)	
Couple x apartment							-0.014	-0.060***	
							(0.009)	(0.011)	
Age	-0.000	-0.002***		-0.002***	-0.002***		-0.001*	-0.002***	
	(0.000)	(0.000)		(0.000)	(0.001)		(0.000)	(0.000)	
Income	-0.030***	0.065***		-0.007	0.020*		-0.027***	0.047***	
	(0.008)	(0.009)		(0.009)	(0.011)		(0.006)	(0.007)	
College	-0.003	0.004		-0.002	0.007		-0.003	0.006*	
	(0.003)	(0.004)		(0.004)	(0.006)		(0.003)	(0.004)	
Self-employed	-0.018	0.013		-0.025	0.012		-0.023**	0.002	
	(0.012)	(0.012)		(0.019)	(0.025)		(0.010)	(0.012)	
School-age children x 1st quarter	-0.000	-0.009*		0.006	-0.022*		0.000	-0.009*	
	(0.006)	(0.006)		(0.013)	(0.012)		(0.006)	(0.005)	
School-age children x 2nd quarter	-0.006	-0.003		-0.009	-0.001		-0.008*	-0.006	
	(0.005)	(0.005)		(0.010)	(0.009)		(0.005)	(0.005)	
School-age children x 3rd quarter	0.003	-0.003		0.022*	0.013		0.004	-0.003	
	(0.006)	(0.006)		(0.012)	(0.011)		(0.005)	(0.005)	
School-age children x 4th quarter	-0.003	-0.016		-0.010	0.001		-0.000	-0.012	
	(0.010)	(0.011)		(0.022)	(0.021)		(0.010)	(0.009)	
First-time buyer			-0.001			0.002			-0.004
			(0.004)			(0.006)			(0.004)
Out-of-town buyer			0.010**			0.002			0.006*
			(0.004)			(0.007)			(0.004)
Assessed value (log)			0.440***			0.532***			0.506***
			(0.032)			(0.024)			(0.019)
Constant			4.014***			3.541***			3.648***
			(0.219)			(0.159)			(0.132)
Additional controls:									
Property characteristics		No			No			No	
Location		No			No			No	
Property fixed effects		Yes			Yes			Yes	
Quarter fixed effects		Yes			Yes			Yes	
Year fixed effects		Yes			Yes			Yes	
Pseudo R2		0.725			0.856			0.761	
Number of observations		23,213			9,791			33,004	

Chapter 2

Reference dependence in the housing market

Reference Dependence in the Housing Market*

Steffen Andersen Cristian Badarinza Lu Liu
Julie Marx and Tarun Ramadorai†

Abstract

We model listing decisions in the housing market, and structurally estimate household preference and constraint parameters using comprehensive Danish data. Sellers optimize expected utility from property sales, subject to down-payment constraints, and internalize the effect of their choices on final sale prices and time-on-the-market. The data exhibit variation in the listing price-gains relationship with "demand concavity;" bunching in the sales distribution; and a rising listing propensity with gains. Our estimated parameters indicate reference dependence around the nominal purchase price and modest loss aversion. A new and interesting fact that the canonical model cannot match is that gains and down-payment constraints have interactive effects on listing prices.

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†Andersen: Copenhagen Business School, Email: san.fi@cbs.dk. Badarinza: National University of Singapore, Email: cristian.badarinza@nus.edu.sg. Liu: Imperial College London, Email: l.liu16@imperial.ac.uk. Marx: Copenhagen Business School, Email: jma.fi@cbs.dk. Ramadorai (Corresponding author): Imperial College London, Tanaka Building, South Kensington Campus, London SW7 2AZ, and CEPR. Tel.: +44 207 594 99 10, Email: t.ramadorai@imperial.ac.uk.

1 Introduction

Housing is typically the largest household asset, and mortgages, typically the largest liability (Campbell, 2006, Badarinza et al. 2016, Gomes et al. 2020). Decisions in the housing market are highly consequential, and are therefore a rich and valuable source of field evidence on households' underlying preferences, beliefs, and constraints. An influential example is the finding that listing prices for houses rise sharply when their sellers face nominal losses relative to the initial purchase price, originally documented by Genesove and Mayer (2001), and reconfirmed and extended in subsequent literature (see, e.g., Engelhardt (2003), Anenberg, 2011, Hong et al. 2019, and Bracke and Tenreyro 2020). This finding has generally been accepted as prima facie evidence of reference-dependent loss aversion (Kahneman and Tversky, 1989, Köszegi and Rabin, 2006, 2007).

Mapping these facts back to underlying preference parameters requires confronting challenges not fully addressed by the extant literature. A rigorous mapping permitting quantitative assessment of parameter magnitudes requires an explicit model of reference-dependent sellers. A plausible model would incorporate additional realistic constraints, such as the fact that optimizing sellers' listing decisions may be disciplined by demand-side responses.[1] Moreover, such a model would predict the behavior of a range of observables in addition to prices—which can be harnessed to accurately pin down parameters. For example, recent work assessing reference dependence in the field extracts information from transactions quantities (see, e.g., Kleven, 2016 and Rees-Jones, 2018), suggesting new moments to match in the residential housing market setting.

In this paper, we develop a new model of house selling decisions incorporating realistic housing market frictions. We structurally estimate the parameters of the model using a large and granular administrative dataset which tracks the entire stock of Danish housing, and the universe of Danish listings and housing transactions between 2009 and 2016, matched to household demographic characteristics and financial information. These rich data also yield

[1] Recent progress has been made on documenting the shape of housing demand (e.g., Guren, 2018), but it is important to understand how this affects inferences about the relationship between listing prices and sellers' "potential gains".

several new facts about household decisions that we cannot match using canonical model features, making them targets for future theoretical work.

In our model, sellers face an extensive margin decision of whether to list, as well as an intensive margin choice of the listing price. Sellers maximize expected utility both from the final sale price of the property as well as (potentially asymmetrically) from any gains or losses relative to a fixed reference price, which we simply set to the nominal purchase price of the property. We adopt a standard piecewise linear formulation of reference-dependent utility, characterized by two parameters: η captures how gains are weighed relative to the utility of the final sale price, and λ captures the asymmetric disutility of losses, i.e., conventionally, when $\lambda > 1$, sellers are loss averse. Sellers enjoy additional "gains from trade" from successful sales, receive an outside option utility level otherwise, and face down-payment constraints à la Stein (1995). Sellers take into account how their choices affect outcomes, i.e., the probability of sale as well as the final sale price, given housing demand.

We summarize a few important insights from the model here. When sellers exhibit "linear reference dependence" ($\eta > 0$, i.e., gains and losses matter to sellers, but $\lambda = 1$, i.e., there is no asymmetry between gains and losses), optimal listing premia decline linearly with "potential gains" (the difference between the expected sale price and the reference price) accrued since purchase. Intuitively, such linearly reference-dependent sellers facing losses require a greater final sales price to elevate the total utility received from a successful sale above that of the outside option. This leads them to raise (lower) listing prices in the face of potential losses (gains).[2] In addition, if sellers are loss averse, with $\lambda > 1$, then optimal listing premia slope up more sharply when sellers face potential losses than when they face potential gains, reflecting the asymmetry in underlying preferences.

These predictions on listing premia are mirrored in the behavior of quantities. With linear reference dependence, completed transactions more frequently occur at realized gains (when the final sales price exceeds the reference price) than at realized losses. Put differently, $\eta > 0$ implies a shift of mass to the right in the distribution of transactions along the realized

[2]In the trivial case of no reference dependence, i.e., when $\eta = 0$, the model predicts that optimal listing premia are simply flat in potential gains.

gains dimension, relative to the distribution when $\eta = 0$. With loss aversion, there is, in addition, sharp bunching of transactions precisely at realized gains of zero, and a more pronounced shift of mass of transactions away from realized losses.

Reference dependence and loss aversion also affect the extensive margin. The model predicts that the propensity to list rises in potential gains if $\eta > 0$. When $\lambda > 1$, there is also a pronounced decline over the domain of potential losses. Accounting for the extensive margin decision additionally helps to clean up inferences on the intensive margin, which can otherwise be biased by the drivers of selection into listing.

This discussion suggests that mapping reduced-form facts to underlying preference parameters is straightforward, but several key confounds can interfere. For one, the model reconfirms an issue recognized in prior work (e.g., Genesove and Mayer, 1997, 2001), that downsizing aversion à la Stein (1995) is difficult to separate from loss aversion. Down-payment constraints on mortgages create an incentive for households to "fish" with higher listing prices, since household leverage magnifies declines in collateral value, severely compressing the size of houses into which households can move. This effect of household leverage strongly manifests itself in listing prices in the data, but we document significant independent variation with potential gains, allowing us to cleanly identify loss aversion.

Second, accurate measurement of sellers' "potential gains" is important for our exercise. We confirm that the hedonic model that we employ to predict house prices in our main analysis fits the data with high explanatory power ($R^2 = 0.86$), and that our empirical work is robust to alternative house price prediction approaches. Third, relatedly, as Genesove and Mayer (2001), Clapp et al. (2018), and others note, variation in the unobservable property quality and potential under- or over-payment at the time of property purchase are important sources of measurement error. As we describe later, we adopt a wide range of strategies to check robustness to this possible confound.[3]

Fourth, the shape of demand is very important for model outcomes. If sale probabilities

[3]This includes estimation with property-specific fixed effects, applying bounding strategies previously proposed in the literature (Genesove and Mayer, 2001), utilizing an instrumental variables approach proposed by Guren (2018), and employing a Regression Kink Design (Card et al., 2015b)

respond linearly and negatively to higher listing prices ("linear demand"), there are material incentives to set low list prices to induce quick sales. However, Guren (2018) shows that U.S. housing markets are characterized by "concave demand," i.e., past a point, lowering list prices does not boost sale probabilities, but does negatively impact realized sale prices; we confirm this finding in the Danish data.[4] The model reveals that this can generate a nonlinear optimal listing price schedule even without any underlying loss aversion. Intuitively, in the face of linear demand, a seller with $\eta > 0$ and $\lambda = 1$ linearly lowers list prices with potential gains, focusing on inducing a swift sale. However, when facing concave demand, lowering list prices past a point is unproductive, leading to an observed "flattening out" in the optimal listing price schedule, which is then nonlinear even though $\lambda = 1$. A related and important observation from the model is that sharp demand responses to raising listing prices are associated with weaker listing price responses to losses, and vice versa.

Keeping these potential confounds in mind, we outline the main facts in the data. First, the listing price schedule has the characteristic "hockey stick" shape first identified by Genesove and Mayer (2001), rising substantially as expected losses mount, and virtually flat in gains. Our estimates are similar in magnitude to those in that paper despite the differences in location, sample period, and sample size.[5] Second, listing premia vary considerably across regional housing markets in Denmark which exhibit varying degrees of demand concavity. This variation is consistent with the model: steep listing premia responses to losses are observed in markets with weaker demand concavity, and vice versa. These regional moments provide additional discipline to our structural estimation exercise and help account for the demand-concavity confound. Third, we see sharp bunching in the sales distribution at realized gains of zero, and a significant shift in mass in the distribution of sales towards realized gains and away from realized losses. Fourth, we estimate listing propensities for the entire Danish housing stock of over 5.5 million housing units as a function of potential

[4] We also show using these data that there are substantial increases in the *volatility* of time on the market associated with higher listing premia, a new and important observation.

[5] In the original Genesove and Mayer sample of Boston condominiums between 1990 and 1997 [N=5,792], list prices rise between 2.5 and 3.5% for every 10% nominal loss faced by the seller. We find rises of 4.4 and 5.4% for the same 10% nominal loss in the Danish data of apartments, row houses, and detached houses between 2009 and 2016 [N=173,065].

gains. There is a visible increase in the propensity to list houses on the market as potential gains rise, and the slope appears more pronounced over the potential loss domain than the potential gain domain.

Taken together, these facts appear consistent with underlying preferences that are both reference dependent and loss averse around the original nominal purchase price of the house. To more rigorously map these facts back to the model, we structurally estimate seven model parameters using seven selected moments from the data (including those described above) using classical minimum distance estimation in this exactly identified system. The resulting point estimates yield $\eta = 0.948$ (*s.e.* 0.344), meaning that gains count about as much as final prices for final utility, and $\lambda = 1.576$ (*s.e.* 0.570), a modest degree of loss aversion, lower than early estimates between 2 and 2.5 (e.g., Kahneman et al. 1990, Tversky and Kahneman, 1992), but closer to those in more recent literature (e.g., Imas et al. 2016 find $\lambda = 1.59$). The role of concave demand is important for these parameter estimates—in a restricted model in which we assume that demand is (counterfactually) linear, estimated $\eta = 0.750$ (*s.e.* 0.291) and $\lambda = 3.285$ (*s.e.* 0.867).[6] This strongly reinforces a broader message (see, e.g., Blundell, 2017) that realistic frictions need to be incorporated when mapping reduced-form facts from the data to inferences about deeper underlying parameters, strengthening the case for applying a structural behavioral approach (DellaVigna (2009, 2018)) to field evidence. Finally, the estimated parameters also reveal strong evidence of the down-payment channel originally identified by Stein (1995), reveal significant "gains from trade" from successful house listings, and highlight that there are substantial (psychological and transactions) costs associated with listing.

The model does a good job of matching the selected moments with plausible preference parameters. However as an out-of-sample exercise, we conduct a broader evaluation of how the model matches the entire surface of the listing premium along the home equity and gains dimensions. A novel pattern that we uncover, and that our model cannot match, is that

[6]This also highlights that frictions in matching in the housing market are another important part of the explanation for the positive correlation between volume and price observed in housing markets, an original motivation for the mechanisms identified by both Stein (1995) and Genesove and Mayer (2001)—both of which our model incorporates.

home equity and expected losses have interactive effects on listing prices in this market. To be more specific, when home equity levels are low, i.e., when down-payment constraints are tighter, households set high listing prices that vary little around the nominal loss reference point. In contrast, households that are relatively unconstrained set listing prices that are significantly steeper in expected losses. Households' listing price responses to down-payment constraints are also modified by their interaction with nominal losses. Mortgage issuance by banks in Denmark is limited to an LTV of no greater than 80%,[7] and for households facing nominal losses since purchase, listing prices rise visibly as home equity falls below this down-payment constraint threshold of 20%. But for households expecting nominal gains, there is a strong upward shift in this constraint threshold (i.e., to values above 20%) in the *level* of home equity at which they raise listing prices. We discuss these findings and conjecture mechanisms to explain them towards the end of the paper; we view them as potential targets for future theoretical work.

The paper is organized as follows. Section 2 introduces the model of household listing behavior. Section 3 discusses the construction of our merged dataset, and provides descriptive statistics about these data. Section 4 introduces the moments that we use for structural estimation and uncovers new facts about the behavior of listing prices and listing decisions. Section 5 describes our structural estimation procedure, and reports parameter estimates. Section 6 describes validation exercises, and highlights areas where the model falls short in explaining features of the data. Section 7 concludes.

2 A Model of Household Listing Behavior

We develop a model in which a household (the "seller"), optimally decides on a listing price (the "intensive margin"), as well as whether or not to list a house (the "extensive margin"). The model framework can flexibly embed different preferences and constraints that have commonly been used to explain patterns in listing behavior. In this section we describe the

[7] We later describe the precise institutional features of the Danish setting, which permits additional non-mortgage borrowing at substantially higher rates for higher LTV mortgages.

main features and specific predictions of the model, which we later structurally estimate to recover key preference and constraint parameters from the data.

2.1 General Framework

The market consists of a continuum of sellers and buyers of residential property. There are two periods in the model: in period 0, some fraction of property owners receive a shock $\theta \sim$Uniform$(\theta_{\min}, \theta_{\max})$, and decide (i) whether or not to put their property up for sale, and (ii) the optimal listing price in case of listing. This "moving shock" θ can be thought of as a "gain from trade" (Stein, 1995), i.e., a boost to lifetime utility which sellers receive in the event of successfully selling and moving, which captures a variety of reasons for moving, including labor market moves to opportunity, or the desire to upsize arising from a newly expanded family. In period 1, buyers visit properties that are up for sale. If the resulting negotiations succeed, the property is transferred to the buyer for a final sale price. If negotiations fail, the seller stays in the property, and a receives a constant level of utility $\underline{u}$.

We seek to uncover the structural relationship between listing decisions and seller preferences and constraints. To sharpen this focus, we model buyer decisions and equilibrium negotiation outcomes in reduced-form, and focus on recovering seller policy functions from this setup. In particular, let L denote the listing price set by the seller; $\widehat{P}$ be a measure of the "expected" or "fundamental" property value;[8,9] $\ell = L - \widehat{P}$ be termed the listing premium; let α denote the probability that a willing buyer will be found; and P denote the final sale price resulting from the negotiation between buyer and seller where $P(\ell) = \widehat{P} + \beta(\ell)$.

[8]Guren (2018) assumes that the buyer's expected value is given by the average listing price in a given zip code and year. This allows for more flexibility, allowing listing prices to systematically deviate from hedonic/fundamental property values across time and locations. We begin with a simpler benchmark, setting $\widehat{P}$ to the fundamental/hedonic value of the house in the interests of internal consistency of the model. As we show later, this distinction does not play a significant role in our empirical work, as Denmark has a relatively homogenous and liquid housing market, and we show that the listing premium based on hedonic prices more strongly predicts a decrease in the probability of sale than the alternative based on average listing prices in a direct comparison in the online appendix.

[9]In the model solution and calibration exercise, we normalize $\widehat{P}$ to 1. All model quantities can therefore be thought of as being expressed in percentages (which we later map to logs, relying on the usual approximation), to be consistent with the definitions of gains/losses and home equity employed in our empirical work.

A typical seller's decision in period 0 can be written as:

$$\max_{s\in\{0,1\}}\left\{(s)\max_{\ell}\underbrace{[\alpha(\ell)\left(U\left(P(\ell),\cdot\right)+\theta\right)+(1-\alpha(\ell))\underline{u}-\varphi]}_{EU(\ell)}+(1-s)\underline{u}\right\} \tag{1}$$

The seller decides on the extensive margin of whether ($s=1$) or not ($s=0$) to list, as well as the listing premium ℓ, to maximize expected utility from final sale of the property. For a listed property, there are two possible outcomes in period 1, which depend on ℓ. With probability $\alpha(\ell)$ the negotiation succeeds, and the seller receives utility from selling the property for an equilibrium price $P(\ell)=\widehat{P}+\beta(\ell)$. With probability $1-\alpha(\ell)$ the listing fails, in which case the seller falls back to their outside option level of utility $\underline{u}$. In addition, owners who decide to list incur a one-time cost φ, which is sunk at the point of listing—all utility costs associated with listing (e.g., psychological "hassle factors", search, listing and transaction fees) are captured by this single parameter.

When making these listing decisions, the seller takes $\alpha(\ell)$ and $\beta(\ell)$, i.e., the "demand" functions, as given; we estimate these functions in the data as a reduced-form for equilibrium outcomes in the negotiation process in period 1, which the seller internalizes when optimizing utility. As in Guren (2018), we note that sufficient statistic formulas (Chetty, 2009) for equilibrium outcomes are mappings between sale probabilities $\alpha(\ell)$, final sale prices $P(\ell)=\widehat{P}+\beta(\ell)$, and listing premia ℓ. In particular, the realized premium $\beta(\ell)$ of the final sales price P over the expected property value $\widehat{P}$, and the probability of a quick sale $\alpha(\ell)$ arise from the seller's listing behavior, and the subsequent negotiation process with the buyer. This assumption simplifies the model, and allows us to more closely focus on our goal, namely, extracting the underlying parameters of seller utility and constraints.[10]

The functions $\alpha(\ell)$ and $\beta(\ell)$ restrict the seller's action space, and capture the basic trade-off that sellers face: a larger ℓ can lead to a higher ultimate transaction price, but decreases the probability that a willing buyer will be found within a reasonable time frame.[11] These

[10]As we describe later, we do allow for the seller to perceive $\alpha(\ell)$ differently from the (ex-post) estimated mapping function in the data by adding a parameter δ to the model, i.e., the seller maximizes subject to their perceived $(\alpha(\ell)+\delta)$ probability.

[11]In our estimation, we define a *period* as equal to six months. In this case, the function $\alpha(\ell)$ captures

points capture the link between listing premia, final realized sales premia, and time-on-the-market or TOM originally detected by Genesove and Mayer (2001). In the remainder of the paper, we refer to these two functions $\alpha(\ell)$ and $\beta(\ell)$ collectively as *concave demand*, following Guren (2018), who documents using U.S. data that above average list prices increase TOM (i.e., they reduce the probability of final sale), while below average list prices reduce seller revenue with little effect on TOM. We find essentially the same patterns in the Danish data.

We next describe the components of $U(P(\ell), \cdot) = u(P(\ell), \cdot) - \kappa(P(\ell), \cdot)$, which allows us to nest a range of preferences $u(P(\ell), \cdot)$, including reference-dependent loss-aversion à la Kahneman and Tversky (1979) and Köszegi and Rabin (2006, 2007), as well as down-payment constraints $\kappa(P(\ell), \cdot)$ à la Stein (1995).

2.2 Reference-Dependent Loss Aversion

We adopt a standard formulation of reference-dependent loss averse preferences, writing $u(P(\ell), \cdot)$ as:

$$u(P(\ell), R) = \begin{cases} P(\ell) + \lambda\eta G(\ell), & \text{if } G(\ell) < 0 \\ P(\ell) + \eta G(\ell), & \text{if } G(\ell) \geq 0 \end{cases}. \tag{2}$$

In equation (2), the seller's reference price level is R, which we simply assume is fixed, and in our empirical application, we set R to the original nominal purchase price of the property.[12] Realized gains $G(\ell)$ relative to this reference level are then given by $G(\ell) = P(\ell) - R$.

The parameter η captures the degree of reference dependence. Sellers derive utility both from the terminal value of wealth (i.e. the final price P realized from the sale), as well as from the realized gain G relative to the reference price R.

The parameter $\lambda > 1$ governs the degree of loss aversion. This specification of the

the probability that the transaction goes through within a time frame of six months after the initial listing.

[12]While this is a restrictive assumption, we find strong evidence to suggest the importance of this particular specification of the reference point in our empirical work. We follow Blundell (2017), trading off a more detailed description of the decision-making problem in the field against stronger assumptions that permit measurement of important underlying parameters.

problem assumes that utility is piecewise linear in nominal gains and losses relative to the reference point, with a kink at zero, and has been used widely to study and rationalize results found in the lab (e.g., Ericson and Fuster, 2011), as well as in the field (e.g., Anagol et al., 2018).

2.2.1 State Variables

In the model, seller decisions are determined by four state variables, namely, the moving shock θ, the hedonic value of the property $\widehat{P}$, the reference point R, and the outside option level $\underline{u}$. To map model quantities more directly to estimates in the data, and to make our setup more directly comparable to extant empirical and theoretical literature, we calculate the seller's expected or "potential" gains $\widehat{G} = \widehat{P} - R$ as a transformation of two of the state variables.[13] Realized gains $G(\ell)$ arise from their "potential" level $\widehat{G}$ plus the markup/premium $\beta(\ell)$, i.e.:

$$G(\ell) = \widehat{G} + \beta(\ell).$$

The remaining two state variables θ and $\underline{u}$ are unobserved, but only the wedge between them $(\underline{u} - \theta)$ is relevant for the seller's decision. Without loss of generality, we therefore set the outside option $\underline{u} = \widehat{P}$, which implies that absent any additional reasons to move $(\theta = 0)$, and with costless and frictionless listings, the seller will be indifferent between staying in their home and receiving the hedonic value in cash. This assumption can equivalently be mapped onto a specification in which the seller does not receive any gains from moving, but experiences a $-\theta$ shock in the event of a failed sale (i.e. the outside option is then rewritten as $\underline{u} = \widehat{P} - \theta$).

We also note that the model implicitly specifies conditions on the relationship between $\underline{u}$ and R. In the online appendix, we discuss this issue in detail. We show there that (i) assuming that R enters (or equals) the outside option (i.e., the consumption utility of

[13]We capture listing behavior by studying the listing premium $\ell = L - \widehat{P}$, which is an innocuous normalization of the listing price L. One way to see this is to note that the regression $\underbrace{L - \widehat{P}}_{\ell} = \rho\,\underbrace{(\widehat{P} - R)}_{\widehat{G}}$ is equivalent to $L = (1+\rho)\widehat{P} - \rho R$. We estimate a version of this regression in the online appendix and verify the original inferences of Genesove and Mayer (2001) using our sample.

households in the event of no sale) generates implausible predictions that we can reject in the data, (ii) if R is used by the seller to "rationally" forecast $\widehat{P}$ (given our normalization of $\underline{u} = \widehat{P}$), the result is innocuous, and doesn't affect any inferences from the model, and (iii) it is potentially possible to reinterpret the model as one of non-rational belief formation (i.e., the seller might view R as the "correct" outside option value), but it is potentially more difficult to rationalize several of the patterns we find in the data (i.e., bunching at just positive gains) with such a model of beliefs.

We next discuss selected predictions of the model to build intuition, and to guide our choice of key moments of the data with which to structurally estimate key parameters.

2.2.2 Optimal Listing Premia

To begin with, consider only the intensive margin decision of the optimal choice of listing premium, and assume that $U\left(P(\ell),\cdot\right) = u(P(\ell),\cdot)$:

$$\max_{\ell}\left[\alpha(\ell)\left(u(P(\ell),\cdot)+\theta\right)+(1-\alpha(\ell))\underline{u}\right] \tag{3}$$

The first-order condition which determines the optimal ℓ^* balances the marginal utility benefit of a higher premium (conditional on a successful sale) against the marginal cost of an increased chance of the transaction failing, and the consequent fall to the outside option utility level.

To aid interpretation, we analytically solve a version of the simple model in equation (3), under the assumption that demand functions $\alpha(\ell) = \alpha_0 - \alpha_1\ell$ and $\beta(\ell) = \beta_0 + \beta_1\ell$ are linear in ℓ (this is an assumption that we later relax to account for concave demand). In this case, the model yields an optimal listing premium schedule which is piecewise linear:

$$\ell^*(\widehat{G}) = \begin{cases} \frac{1}{2}\left(\frac{\alpha_0}{\alpha_1} - \frac{\beta_0}{\beta_1} - \frac{1}{\beta_1}\frac{\theta}{1+\eta}\right) - \frac{1}{2\beta_1}\frac{\eta}{1+\eta}\widehat{G}, & \text{if } \widehat{G} \geq \widehat{G}_0 \\ -\frac{\beta_0}{\beta_1} - \frac{1}{\beta_1}\widehat{G}, & \text{if } \widehat{G} \in (\widehat{G}_1, \widehat{G}_0) \\ \frac{1}{2}\left(\frac{\alpha_0}{\alpha_1} - \frac{\beta_0}{\beta_1} - \frac{1}{\beta_1}\frac{\theta}{1+\lambda\eta}\right) - \frac{1}{2\beta_1}\frac{\lambda\eta}{1+\lambda\eta}\widehat{G}, & \text{if } \widehat{G} \leq \widehat{G}_1, \end{cases} \tag{4}$$

where $\widehat{G}_0$ and $\widehat{G}_1$ are levels of potential gains determined by underlying model parameters.[14]

Figure 1 illustrates how equation (4) varies with the underlying parameters characterizing preferences.

In the case of no reference dependence ($\eta = 0$), utility derives purely from the terminal house price. In this case, the top left-hand plot shows that ℓ^* is unaffected by the reference price R.

In the case of linear reference dependence ($\eta > 0$, $\lambda = 1$), there is a negatively-sloped linear relationship between ℓ^* and $\widehat{G}$. In this case, R does not affect the marginal benefit of raising ℓ^*, but it does affect the marginal cost, as it affects the distance between $\underline{u}$ and the achievable utility level in the event of a successful transaction. Intuitively, if the household can realize a gain (i.e., when R is sufficiently low), the utility from a successful sale rises. The resulting ℓ^* will therefore be lower, as the household seeks to increase the probability that the sale goes through. The opposite is true when the household faces a loss in the event of a completed sale (i.e., when R is sufficiently high), which consequently results in a higher ℓ^*.[15]

In the case of (reference dependence plus) loss aversion ($\eta > 0$, $\lambda > 1$), the kink in the piecewise linear utility function leads to a more complex piecewise linear pattern in ℓ^*, which determines the gains that sellers ultimately realize. There is a unique level of potential gains, $\widehat{G}_0$, which maps to a realized gain of *exactly* zero (recall that $G(\ell^*) = \widehat{G} + \beta(\ell^*)$). Sellers with potential gains below $\widehat{G}_0$ want to avoid realizing a loss, meaning that they adjust ℓ^* upwards. However, this upward adjustment increases the probability of a failed sale. Beyond some lower limit $\widehat{G}_1$, the costs in terms of the failure probability become unacceptably high relative to the benefit of avoiding a loss, and it becomes sub-optimal to aim for a realized gain of zero. The seller has no choice but to accept the loss at levels of $\widehat{G} < \widehat{G}_1$, but still sets a marginally higher listing premium for each unit loss beyond this point.

[14] We derive the equation explicitly in the online appendix.

[15] As mentioned earlier, it is important to assume that households do not receive utility from simply living in a house that has appreciated relative to their reference point R, i.e. they do not enjoy utility from "paper" gains until they are realized. If this condition does not hold, the model is degenerate in that R is irrelevant both for the choice of the listing premium (intensive margin) and the decision to list (extensive margin). We demonstrate this result analytically in the online appendix.

2.2.3 Bunching Around Realized Gains of Zero

The model reveals that household listing behavior also has material implications for quantities. Loss-averse preferences show up in non-linearities in the schedule of ℓ^* along the $\widehat{G}$ dimension, as well as on the likelihood of transaction completion, and the final price at which these transactions occur. This shows up as shifts in mass in the distribution of completed transactions along the G dimension, additional moments which allow us to pin down underlying utility parameters. In the simple version of the model (assuming linear demand) discussed above, the equation relating potential gains $\widehat{G}$ with final realized gains G is:

$$G(\widehat{G}) = \begin{cases} \beta_0 + \frac{\beta_1}{2}\left(\frac{\alpha_0}{\alpha_1} - \frac{\beta_0}{\beta_1} - \frac{1}{\beta_1}\frac{\theta}{1+\eta}\right) + \left(1 - \frac{1}{2}\frac{\eta}{1+\eta}\right)\widehat{G} & \text{if } \widehat{G} > \widehat{G}_0, \\ 0 & \text{if } \widehat{G} \in [\widehat{G}_1, \widehat{G}_0], \\ \beta_0 + \frac{\beta_1}{2}\left(\frac{\alpha_0}{\alpha_1} - \frac{\beta_0}{\beta_1} - \frac{1}{\beta_1}\frac{\theta}{1+\lambda\eta}\right) + \left(1 - \frac{1}{2}\frac{\lambda\eta}{1+\lambda\eta}\right)\widehat{G} & \text{if } \widehat{G} < \widehat{G}_1. \end{cases} \quad (5)$$

The two bottom panels of Figure 1 illustrate how this relationship varies with underlying utility parameters.

When $\eta = 0$, sellers choose a constant listing premium ℓ^*, which results in a constant realized premium $\beta(\ell^*)$ of actual gains G over potential gains $\widehat{G}$ (bottom left plot), meaning that the distribution of G is a simple parallel shift of the distribution of $\widehat{G}$ (bottom right plot, the black dotted line becomes the purple line).

In the linear reference dependence model ($\eta > 0, \lambda = 1$), sellers with $\widehat{G} < 0$ choose relatively higher ℓ^*. This lowers the likelihood that willing buyers will be found, meaning that the likelihood of observing transactions in this domain of $\widehat{G}$ is lower. However, if these transactions *do* go through, the associated G will be higher, shifting mass in the final sales distribution towards $G > 0$ (bottom right plot, the black dotted line becomes the green line).

The effect mentioned above is especially pronounced if sellers are loss averse, i.e., when $\lambda > 1$, in which case the model predicts bunching $(F(\widehat{G_0}) - F(\widehat{G_1}))$ in the final distribution of house sales precisely at $G = 0$ (bottom left plot, black line and bottom right plot black solid line), and greater mass in the distribution when $G > 0$, coming from even less mass when $G < 0$ (bottom right plot, the black dotted line becomes the black solid line).

In the discussion thus far, to build intuition about the effect of the underlying parameters characterizing preferences, we focused on the intensive margin, made several assumptions about the shape of demand, and assumed away other frictions and constraints. We next outline the predictions of the model in the broader case when we consider the extensive margin decision, and then turn to discussing two important potential confounds, namely, concave demand, and the effect of financial constraints.

2.2.4 Extensive Margin

In the discussion thus far, we ignored the seller's decision of whether or not to list. In the model, any force inducing a wedge between the expected utility from a successful listing and the outside option $\underline{u}$ affects decisions along the intensive margin, but can also push the seller towards deciding that listing is sub-optimal. In particular, the model predicts that sellers with lower $\widehat{G}$ are less likely to list. This clear prediction allows us to exploit the relationship of the listing propensity and $\widehat{G}$ as an additional moment to inform structural estimation of underlying preference parameters.[16]

Another important observation here here is that modeling the extensive margin decision is also important to account for any selection effects that may drive patterns of observed intensive margin listing premia in the data, an issue that the prior literature (e.g., Genesove and Mayer, 1997, 2001, Anenberg, 2011, Guren, 2018) has been unable to control for as a result of data limitations. For example, if sellers that decide not to list are more conservative (i.e., they set lower listing premia), and those who decide to list are more aggressive (i.e., setting higher listing premia) the resulting selection effect would lead to a higher observed non-linearity in listing premia around reference points that would bias parameter estimates

[16] Bunching in the distribution of realized house sales captures *ex post*-negotiation outcomes, and extensive margin decisions capture sellers' *ex ante* listing behaviour, i.e., these two moments are informative about different phases in the listing/selling decision.

and inferences conducted only using the intensive margin.[17]

The moving shock θ (which alters the distance between the outside option and the utility from a successful listing) is a key model component that helps to capture such selection effects. Conditional on the moving shock, the listing decision is a simple binary choice. This means that accounting for the distribution of shocks, as we do in the model, allows us to capture the variation in listing decisions and to calculate average listing premia in the population. These average listing premia incorporate the endogenous first-stage selection effects and can be mapped directly back to the data.

There are more subtle implications of the model linking the extensive and the intensive margins. High realizations of θ affect the listing decision, and push the seller towards setting higher listing premia. However, this force can move ℓ into regions of concave demand (which we discuss in detail in the next subsection) in which the response of buyers is more (or less) pronounced, because of nonlinearities in $\alpha(\ell)$. This in turn means that θ variation can affect the observed magnitude of the seller's responses to $\widehat{G}$, smoothing and blurring the kinks in the model-implied ℓ^* profile. The online appendix illustrates this with a specific example, showing that the characteristic "hockey stick" shape of the average listing premium profile can result from averaging the three-piece-linear form of the listing premium profile in the case of $\lambda > 1$ across the distribution of θ.

2.3 Concave Demand

The demand functions $\alpha(\ell)$ and $\beta(\ell)$ are a critical determinant of listing behavior and the expected shape of ℓ^* in this model. This can be seen even in the simple case of the linear demand functions posited earlier. Equation (4) shows that when the probability of sale is less sensitive to ℓ (i.e., when α_1 is lower), the marginal cost of choosing a larger listing premium is lower, and therefore the optimally chosen ℓ^* is higher. This intuition carries over to a case in which $\alpha(\ell)$ has the concave shape first identified by Guren (2018), and has important implications for the relationship between ℓ^* and $\widehat{G}$. Figure 2 graphically

[17] We thank Jeremy Stein for useful discussions on this issue.

illustrates this mechanism, positing a concave shape for $\alpha(\ell)$ and considering the effect of varying $\alpha(\ell)$ around $\underline{\ell} = 0$, i.e., the point at which $L = \widehat{P}$ (solid and dashed red lines, right-hand plot).

The left-hand plot in Figure 2 documents the relationship between the optimal listing premium ℓ^* and $\widehat{G}$ in the presence of concave demand. When $\widehat{G} > 0$, the seller's incentive is to set ℓ^* low, since they are motivated to successfully complete a sale and capture gains from trade θ. However, in the presence of concave demand (i.e., as illustrated in the right-hand plot, horizontal $\alpha(\ell)$ when $\ell < \underline{\ell}$; combined with $P(\ell) = \beta_0 + \beta_1 \ell$), lowering ℓ below $\underline{\ell}$ does not boost the sale probability $\alpha(\ell)$, but doing so does negatively impact the realized sale price $P(\ell)$. It is thus optimal for ℓ^* to "flatten out" at the level $\underline{\ell}$.

The tradeoff faced by sellers facing losses $\widehat{G} < 0$ is different—raising ℓ^* helps to offset expected losses, but lowers the probability of a successful sale. When demand concavity increases, i.e., $\alpha(\ell)$ is more steeply negative, the probability of a successful sale falls at a faster rate with increases in ℓ. Figure 6 illustrates this force—moving from the dashed $\alpha(\ell)$ schedule to the solid $\alpha(\ell)$ schedule in the right-hand plot in turn leads to dampening of the slope of ℓ^* in the left-hand plot. In the extreme case in which concave demand has an infinite slope around some level of the listing premium, rational sellers' ℓ^* collapses to a constant—which would be observationally equivalent to the case in which sellers are not reference dependent at all ($\eta = 0$).

The main predictions from the model in this case are: First, the optimal ℓ^* in a linear reference-dependent model ($\eta > 0$, $\lambda = 1$) in the presence of concave demand exhibits a flatter slope in the domain $\widehat{G} > 0$ relative to the case of linear demand. This means that the graph of ℓ^* against $\widehat{G}$ can exhibit a characteristic "hockey stick" shape of the type detected by Genesove and Mayer (2001) even if there is no loss aversion, i.e., $\lambda = 1$. Second, the model predicts a tight link between the shape of $\alpha(\ell)$ and the slope of ℓ^*. We later use this insight to exploit cross-sectional variation in the concavity of demand across different segments of the Danish market to aid structural parameter identification.[18] Third, while we have focused

[18]For example, if $\eta = 0$ in this model, demand concavity does not affect the slope of the ℓ^* profile along the G dimension. In contrast, a high η leads to a high "pass-through" of demand concavity into optimal

our discussion on how concave demand can generate a non-linear listing premium profile, it will also result in effects on transactions volume. That is, concave demand can result in additional shifts of mass towards positive values of realized gains, depending on the level of $\underline{\ell}$, though it will not be associated with sharp bunching of the type associated with loss aversion.

A subtle point here is that any change in the precise specification of the reference point R in the presence of loss aversion will change the location at which bunching is observed. Indeed, heterogeneity in reference points will make it hard to observe the precise location of bunching. To complicate matters further, variations in the level of $\underline{\ell}$ are a confound, potentially rendering it difficult to distinguish models with heterogeneous reference points from models with spatial or temporal variation in $\underline{\ell}$, the point at which demand concavity kicks in. We avoid this complexity in our setup by simply taking the stance that R is the nominal purchase price of the property and evaluating the extent to which we see bunching given this assumption. As we will later see, this turns out to be a reasonable assumption—we observe significant evidence in the data of bunching using this assumption about R, confirming its relevance to sellers.

2.4 Down-payment Constraints

A well-known confound for the estimation of preference parameters from listing premia (see, e.g., Genesove and Mayer (1997, 2001)) is the effect of down-payment constraints, which we account for in the model through the function $\kappa(P(\ell), \cdot)$ (recall that $U(P(\ell), \cdot) = u(P(\ell), \cdot) - \kappa(P(\ell), \cdot)$). Let M denote the level of the household's outstanding mortgage, and γ the required down-payment on a *new* mortgage origination. For a given price level $P(\ell)$, the "realized" home equity position of the household is $H(\ell) = P(\ell) - M$. Under the assumption that H is put towards the down payment on the next home, we can distinguish between constrained (i.e., downsizing-averse) households for which $H(\ell) < \gamma$, and unconstrained households for which $H(\ell) \geq \gamma$.

listing premia.

In the face of binding down-payment constraints, only unconstrained sellers can move to another property of the same or greater value. However, there are several ways in which households could relax these constraints despite legal restrictions on LTV at mortgage initiation (which, as we discuss later, are strictly set at 20% in Denmark). The first is for households to downsize to a less expensive home than $P(\ell)$, or indeed, to move to the rental market—either decision might incur a utility cost. The second is that households can engage in non-mortgage borrowing to fill the gap $\gamma - H(\ell)$. A common approach in Denmark is to borrow from a bank or occasionally from the seller of the property to bridge funding gaps between 80% and 95% loan-to-value (LTV); this is typically expensive.[19] A third (usually unobservable) possibility is that households can bring additional funds to the table by liquidating other assets.[20] We therefore assume that violating the down-payment constraint does not lead the seller to withdraw the sale offer, assuming instead that the seller incurs a monetary penalty of μ per unit of realized home equity below the constraint threshold:[21]

$$\kappa(P(\ell)) = \begin{cases} \mu(\gamma - H(\ell)), \text{ if } H(\ell) < \gamma \\ 0, \text{ if } H(\ell) \geq \gamma \end{cases}. \tag{6}$$

We turn next to describing the data and key estimated moments as a precursor to more rigorous structural estimation of the underlying parameters of the model.

[19]Danish households can borrow using "Pantebreve" or "debt letters" to bridge funding gaps above LTV of 80%. Over the sample period, this was possible at spreads of between 200 and 500 bp over the mortgage rate. For reference, see categories *DNRNURI* and *DNRNUPI* in the Danmarks Nationalbank's statistical data bank.

[20]In Stein (1995), M represents the outstanding mortgage debt net of any liquid assets that the household can put towards the down payment. The granular data that we employ allow us to measure the net financial assets that households can bring to the table to supplement realized home equity. We later verify using these data that our inferences are sensible when taking these additional funds into account.

[21]i.e.,

$$U(P(\ell)) = \begin{cases} u(P(\ell) - \mu(\gamma - H(\ell)), \text{ if } H(\ell) < \gamma \\ u(P(\ell)), \text{ if } H(\ell) \geq \gamma \end{cases}.$$

3 Data

Our data span all transactions and electronic listings (which comprise the overwhelming majority of listings) of owner-occupied real estate in Denmark between 2009 and 2016. In addition to listing information, we also acquire information on property sales dates and sales prices, the previous purchase price of each sold or listed property, rich hedonic characteristics of each property, and a range of demographic characteristics of the households engaging in these listings and transactions, including variables that accurately capture households' financial position at each point in time. Furthermore, we merge the data on the entire housing stock captured in the Danish housing register with the listings data to assess the determinants of the extensive margin listing decision for all properties in Denmark over the sample period. This allows us to assess the fraction of the total housing stock that is listed, and to condition observed listing propensities on functions of the predicted sales price, such as the prospective seller's potential gains relative to the original purchase price, or the prospective seller's potential level of home equity in the property.

Our data link administrative datasets from various sources; all data other than the listings data are made available to us by Statistics Denmark. We briefly describe these data below; the online appendix contains detailed information about data sources, construction, filters, and the process of matching involved in assembling the dataset.

3.1 Property Transactions and other Property Data

We acquire comprehensive administrative data on registered properties, property transactions, property ownership, and hedonic characteristics of properties from the registers of the Danish Tax and Customs Administration (SKAT) and the Danish housing register (Bygnings-og Boligregister, BBR). These data are available from 1992 to 2016. In our hedonic model, described later, we also include the (predetermined at the point of inclusion in the model) biennial property-tax-assessment value of the property that is provided by

SKAT, which assesses property values every second year.[22,23]

Loss aversion and down-payment constraints were originally proposed as explanations for the puzzling *aggregate* correlation between house prices and measures of housing liquidity, such as the number of transactions, or the time that the average house spends on the market. In the online appendix, we show the price-volume correlation in Denmark over a broader period containing our sample period. The plot looks very similar to the broad patterns observed in the US.

3.2 Property Listings Data

Property listings are provided to us by RealView (http://realview.dk/en/), who attempt to comprehensively capture all electronic listings of owner-occupied housing in Denmark. We link these transactions to the cleaned/filtered sale transactions in the official property registers. 76.56% of all sale transactions have associated listing data.[24] For each property listing, we know the address, listing date, listing price, size, and time of any adjustments to the listing price, changes in the broker associated with the property, and the sale or retraction date for the property.

3.3 Mortgage Data

To establish the predicted/potential level of the owner's home equity in each property at each date, we obtain data on the mortgage attached to each property from the Danish

[22]As we describe later, this is the same practice followed by Genesove and Mayer (1997, 2001); it does not greatly affect the fit of the hedonic model, and barely affects our substantive inferences when we remove this variable.

[23]Tax-assessed property values are used for determining tax payments on property value. The appendix describes the property taxation regime in Denmark in greater detail including inheritance taxation; we simply note here that there is the usual "principal private residence" exemption on capital gains on real estate, and that property taxation does not have important effects on our inferences.

[24]We more closely investigate the roughly 25% of transactions that do not have an associated electronic listing. 10% of these transactions can be explained by the different (more imprecise) recording of addresses in the listing data relative to the registered transactions data. The remaining 15% of unmatched transactions can be explained by: (a) off-market transactions (i.e., direct private transfers between friends and family, or between unconnected households); and (b) broker errors in reporting non-publicly announced listings ("skuffesager") to boligsiden.dk. We find that on average, unmatched transactions are more expensive than matched transactions. Sellers of more expensive houses tend to prefer the skuffesalg option for both privacy and security reasons.

central bank (Danmarks Nationalbank), which collects these data from mortgage banks. The data are available annually for each owner from 2009 to 2016, cover all mortgage banks and all mortgages in Denmark and contain information on the mortgage principal, outstanding mortgage balance each year, the loan-to-value ratio, and the mortgage interest rate. If several mortgages are outstanding for the same property, we simply sum them, and calculate a weighted average interest rate and loan-to-value ratio for the property and mortgage in question.[25]

3.4 Owner/Seller Demographics

We source demographic data on individuals and households from the official Danish Civil Registration System (CPR Registeret). In addition to each individual's personal identification number (CPR), gender, age, and marital history, the records also contain a family identification number that links members of the same household. This means that we can aggregate individual data on wealth and income to the household level.[26] We also calculate a measure of households' education using the average length of years spent in education across all adults in the household. These data come from the education records of the Danish Ministry of Education. We source individual income and wealth data from the official records at SKAT, which hold detailed information by CPR numbers for the entire Danish population.

3.5 Final Merged Data

We only keep transactions for which we can measure both nominal losses and home equity, and since the mortgage data run from 2009 to 2016, this imposes the first restriction on the sample. The sample is further restricted to properties for which we know both the ID of the owner, as well as that of the owner's household, in order to match with demographic

[25]The online appendix provides a detailed description of several features of the Danish mortgage market including the conditions under which mortgages are assumable, as well as the effects of the Danish refinancing system (studied in greater detail in Andersen et al. (2020)) on sale and purchase incentives. These features do not materially impact our inferences.

[26]Households consist of one or two adults and any children below the age of 25 living at the same address.

information. Transactions data are available from 1992 to the present, meaning that we can only measure the purchase price of properties that were bought during or after 1992.[27] We exclude foreclosures (both sold and unsold),[28] properties with a registered size of 0, and properties that are sold at prices which are unusually high or low (below 100,000 DKK and above 20MM DKK in 2015, accounting for roughly 0.05% of the total housing stock in Denmark).[29] For listings that end in a final sale, we also drop within-family transactions, transactions that Statistics Denmark flag as anomalous or unusual, and transactions where the buyer is the government, a company, or an organization.[30] We also restrict our analysis to residential households, in our main analysis dropping summerhouses and listings from households that own more than three properties in total, as they are more likely property investors than owner-occupiers.[31]

In the online appendix, we describe the data construction filters and their effects on our final sample in more detail. Once all filters are applied, the sample comprises 214, 508 listings of Danish owner-occupied housing in the period between 2009 and 2016, for both sold (70.4%) and retracted (29.6%) properties, matched to mortgages and other household financial and demographic information.[32] These listings correspond to a total of 191, 843 unique households, and 179, 262 unique properties. Most households that we observe in the data sell one property during the sample period, but roughly 9% of households sell two properties over the sample period, and roughly 1.5% of households sell three or more

[27] In Appendix Table A.2 and Appendix Figure A.39 we further examine properties traded before 1992. Since these properties have no known purchase price, we match them to otherwise similar properties for which we know the purchase price, using two approaches that we describe in the online appendix, with a reasonable success rate. Figure A.39 shows that the main relationships that we find in the main dataset essentially hold in the matched sample using this approach.

[28] The online appendix describes the Danish foreclosure process in detail.

[29] We apply this filter to reduce error in our empirical work, because the market for such unusually priced properties is extremely thin, meaning that predicting the price using a hedonic or other model is particularly difficult.

[30] We apply this filter, as company or government transactions in residential real estate are often conducted at non-market prices—for tax efficiency or evasion purposes in the case of corporations, and for eminent domain reasons in the case of government purchases, for example.

[31] Genesove and Mayer (2001) separately estimate loss aversion for these groups of homeowners and speculators. We simply drop the speculators in this analysis, choosing to focus our parameter estimation in this paper on the homeowners.

[32] The data comprises 173, 065 listings that have a mortgage, and 41, 443 listings with no associated mortgage (i.e., owned entirely by the seller)—we later utilize these subsamples for various important checks.

properties. In addition, we use the entire housing stock, filtered in the same manner as the listing data, comprising $5,540,376$ observations of $807,666$ unique properties to understand sellers' extensive margin decision of whether or not to list the properties for sale.

3.6 Hedonic Pricing Model

To calculate potential gains $\widehat{G}$ (and potential home equity $\widehat{H}$), we require a measure of the expected sale price $\widehat{P}$ for each property-year in the data. To arrive at this measure, we estimate a standard hedonic pricing model on our sample of sold listings and use it to predict prices for the full sample of listed properties, including those that are not sold.[33]

The hedonic model predicts the log of the sale price P_{it} of all sold properties i in each year t:

$$\begin{aligned} \ln(P_{it}) = \xi_{tm} + \beta_{ft}\mathbb{1}_{i=f}\mathbb{1}_{t=\tau} + \boldsymbol{\beta}\mathbf{X_{it}} \\ + \boldsymbol{\beta}_{\mathbf{fx}}\mathbb{1}_{i=f}\mathbf{X_{it}} + \Phi(v_{it}) + \mathbb{1}_{i=f}\Phi(v_{it}) + \varepsilon_{it}, \end{aligned} \tag{7}$$

where $\mathbf{X_{it}}$ is a vector of property characteristics, namely ln(lot size), ln(interior size), number of rooms, bathrooms, and showers, a dummy variable for whether the property was unoccupied at the time of sale or retraction, ln(the age of the building), dummy variables for whether the property is located in a rural area, or has been marked as historic, and ln(distance of the property to the nearest major city). (Most property characteristics in $\mathbf{X_{it}}$ are time-varying, which contributes to the accuracy of the model). ξ_{tm} are year cross municipality fixed effects (there are 98 municipalities in Denmark), and $\mathbb{1}_{i=f}$ is an indicator variable for whether the property is an apartment (denoted by f for flat) rather than a house.[34] $\Phi(v_{it})$ is a third-order polynomial of the previous-year tax assessor valuation of the property.[35] We interact the apartment dummy with time dummies, as well as with the

[33]Later in the paper, we also assess the extent to which gains, losses, and home equity determine the *decision* to list. We estimate a separate hedonic model on a larger data set, including unlisted properties, in order to conduct these additional tests.

[34]In the online appendix, we also include cohort effects ξ_c in the hedonic regression, and continue to find robust evidence of all patterns uncovered in our empirical analysis, showing that intra-cohort variation in gains and losses is also associated with changes in listing premia.

[35]Genesove and Mayer (1997, 2001) also consider tax assessment data in their hedonic model. Impor-

hedonic characteristics and the tax valuation polynomial, to allow for a different relationship between hedonics and apartment prices.

When we estimate the model, the R^2 statistic equals 0.88 in the full sample.[36] The large sample size allows us to include many fixed effects in the model, helping to deliver a better fit. This helps to ameliorate concerns of noise or unobserved quality in the measure $\widehat{P}$, an important concern when estimating the effects of both loss aversion and home equity (e.g., Genesove and Mayer, 1997, 2001, Anenberg, 2011, Clapp, et al., 2018). We also adopt a number of alternative approaches to deal with the important issue of unobserved quality and its effects on our inferences, as we later describe.

4 First Inferences about Model Parameters

In this section, we document patterns in listing premia and sales transactions volumes in the data in relation to measured G and $\widehat{G}$, and informally discuss how these patterns relate to the predictions of the model, especially regarding the primary parameters of interest η and λ. We also explore how the patterns in the data and possible inferences about underlying parameters vary when we account for three important factors. These are: (i) sellers' down-payment constraints, (ii) concave demand, and (iii) robustness to changes in measurement. Before turning to structural estimation that takes the model's predictions to the data more rigorously in the next section, we discuss the robustness of the patterns seen in the data to various estimation approaches and controls.

tantly, the tax assessment valuation is carried out before the time of the transaction, in some cases even many years before. Until 2013, the tax authority re-evaluated properties every second year. The assessment, which is valid from January 1st each year, is established on October 1st of the prior year. In the years between assessments, the valuation is adjusted by including local-area price changes. This adjustment has been frozen since 2013, recording such price changes as of 2011. Only in the case of significant value-enhancing adjustments to a house or apartment would a re-assessment have taken place thereafter—and once again, is pre-determined at the point of property sale.

[36] The online appendix contains several details about the hedonic model and estimates. We also estimate the model in levels rather than logs, with an R^2 of 0.89. Moreover, the R^2 when we eliminate the tax assessor valuation from the hedonic characteristics is 0.77. To check the robustness of our results to the specification of the hedonic model, we also amend it in various ways as outlined in the appendix. Our results are qualitatively, and for the most part, quantitatively unaffected by these amendments.

4.1 Listing Premia in the Data

Armed with the hedonic pricing model, we estimate listing premia in the data as $\ell = \ln L - \widehat{\ln P}$, where L is the reported initial listing price observed in the data.[37] Mean (median) ℓ is 12.7% (11.3%), and $\ell > 0$ (< 0) for 75% (25%) of the sample. We also estimate potential gains $\widehat{G} = \widehat{\ln P} - \ln R$, where R is set to the nominal purchase price of the property. Mean (median) $\widehat{G}$ estimated in this way is 36% (28%), and 23% (77%) of property-years have $\widehat{G} < 0$ ($\widehat{G} > 0$). The online appendix plots the distributions of these and other variables.

In Figure 3 we plot the average observed listing premium (on the vertical axis) for each percentage bin of potential gains (on the horizontal axis). Sellers who hold properties that have appreciated (declined in value) since the initial purchase choose lower (higher) listing premia. Importantly, this negative relationship is visible not only in the potential loss domain (i.e., $\widehat{G} < 0$), but also across different values in the potential gain domain (i.e., $\widehat{G} > 0$). This is consistent with the predictions of a model with reference dependence $\eta > 0$. Moreover, as we move from the gain to the loss domain, the slope becomes much more pronounced, i.e., sellers react much more aggressively to every unit decrease in potential returns when $\widehat{G} < 0$. For potential gains in the neighbourhood of zero, this "hockey stick" pattern is consistent with the predictions of a model with loss aversion $\lambda > 1$. However, in the piecewise linear formulation that we consider, loss aversion also predicts a flattening out of the listing premium profile deeper into the loss domain, which is not visible in the plot.

While these patterns provide prima facie evidence of the underlying parameters of the seller's utility, we must be wary of such inferences given the influence of three important confounding factors discussed above, namely: (i) concave demand, (ii) the extensive margin, which smooths out the locations of kinks, and can lead to selection effects, and (iii) sellers' financial/down-payment constraints. Keeping these issues in mind, we next discuss additional evidence available from the analysis of transactions volumes.

[37] We confirm, estimating Genesove and Mayer's (2001) specifications on our data (see online appendix), that the coefficient on $\widehat{\ln P}$ in our data using ther regression, controlling for a range of other determinants, is close to 1. We discuss below how our results are robust to using the alternative approach of Genesove and Mayer (2001), and discuss identification and measurement concerns in greater detail below as well.

4.2 Bunching of Realized Sales

Figure 4 plots the distribution of property sales across the dimension of realized gains ($\ln P - \ln R$)—each dot shows the empirical frequency of sales (y-axis) occurring in each 1 percentage point bin of realized gains (x-axis). We overlay on this plot (as a dotted line) the empirical frequency of realized sales (i.e., the same y-axis) occurring in each 1 percentage point of *potential* gains $\widehat{\ln P} - \ln R$ (i.e., a different x-axis). Observing the counterfactual is difficult in most settings which attempt to estimate loss aversion using bunching estimators (e.g., Rees-Jones 2018 cleverly extracts evidence of loss aversion from U.S. tax returns data, where it is difficult to measure "expected tax avoidance costs and benefits"). The distribution of sales with respect to pre-listing potential gains can serve as one possible counterfactual, as we describe in greater detail below.[38]

Figure 4 shows significant bunching of transactions in the positive domain of realized gains G, with a sharp "spike" around $G = 0$, and with significant mass extending further into the domain $G > 0$.[39] While the spike is clearly evident, more information can be extracted about model parameters from the broader distribution of sales across realized gains, especially when we compare it to the distribution of sales across potential gains $\widehat{G}$. This is because in the model when $\eta > 0$, as mentioned earlier, the mapping between $\widehat{G}$ and G occurs through the choice of ℓ^*, and the associated probability of sale. This mapping results in mass in the final sales distribution shifting towards sales with realized $G > 0$. In contrast, when $\eta = 0$, the model predicts that the distribution of G is simply a constant linear transformation of the distribution of $\widehat{G}$. The precise position of the pronounced jump in the distribution at $G = 0\%$, and the distribution of mass to the left and right of this point relative to the counterfactual are also informative about λ. When $\lambda > 1$, the model predicts a jump in the final distribution of house sales precisely at $G = 0$, additional mass in this

[38] We also use alternative approaches to measure this counterfactual density, following Chetty et al. (2011) and Kleven (2016), and fitting a flexible polynomial to the empirical frequency distribution. When doing so, we exclude bins near the threshold, and extrapolate the fitted distribution to the threshold, excluding one bin on each side of the zero gain bin, i.e. $j \in \{-1\%, 1\%\}$, with a polynomial order of 7. The results, reported in the Online Appendix, are robust to other polynomial orders and to variations of the excluded range, and generate similar (but less cleanly estimated) results on the excess bunching mass.

[39] The plot also reveals a small but visible "hole" just to the left of $G = 0$, that may be evidence of a notch in preferences—an important additional feature of the data that we are currently investigating.

distribution just to the right of this point, and relatively lower mass in the loss domain, to the left of $G = 0$. The pronounced bunching that we observe precisely at the point $G = 0$ also offers empirical support (which is essentially non-parametric, since it does not require reliance on a hedonic or other model) for the choice of R as the nominal purchase price (see Kleven, 2016, for a discussion of bunching at reference points).

4.3 Extensive Margin: Probability of Listing

As discussed earlier, understanding the seller's decision of whether or not to list is important for at least two reasons. First, the model makes predictions about this decision, in addition to predicting patterns of listing premia and transactions volumes. Second, accounting for this decision helps to correct for possible selection effects that may drive patterns of observed intensive margin listing premia in the data. This is an issue that the prior literature (e.g., Genesove and Mayer, 1997, 2001, Anenberg, 2011, Guren, 2018) has been unable to control for as a result of data limitations.

To understand the decision to list, we turn to data on the total housing stock in Denmark, corresponding to $12,565,190$ property-years in the data, once merged with the listings data. We compute the unconditional average annual listing propensity, which is 3.75% of the housing stock (corresponding to between 2% and 4% of the housing stock listed across sample years).[40] Figure 8 plots the listing propensity at each level of $\widehat{G}$, which comes from estimating $\widehat{\ln P}$ for all properties in Denmark for which we have data on the nominal purchase price R. The figure shows a mild, but visible increase in the probability of listing as $\widehat{G}$ increases, which is evident when $\widehat{G} > 0$, but more pronounced when $\widehat{G} < 0$. This pattern is once again apparently consistent with levels of $\eta > 0$ and $\lambda > 1$.

[40] We do not attempt to use the model to explain the average propensity to list, as this exercise is beyond the scope of this paper. It would require us to take a strong stance on the factors that drive the moving decision, which we currently summarize using our estimates of θ.

4.4 Confounding Factors

4.4.1 Down-payment Constraints and Home Equity

To account for the role of down-payment constraints, for each observation in the data, we calculate the seller's potential home equity level $\widehat{H} = \widehat{\ln P} - \ln M$, where $\widehat{\ln P}$ is estimated using our hedonic model as before, and M is the outstanding mortgage balance reported by the household's mortgage bank each year.[41] Mean (median) $\widehat{H}$ is 27% (25%), and 77% (23%) of property-years have $\widehat{H} < 0$ ($\widehat{H} \geq 0$). Modal $\widehat{H}$ is around 22%, which is to be expected, as Denmark has a constraint on the issuance of mortgages—the Danish Mortgage Act specifies that LTV at issuance by mortgage banks is restricted to be 80% or lower.[42] Clearly, $\widehat{G}$ and $\widehat{H}$ are jointly dependent on $\widehat{\ln P}$, but there are multiple other factors that influence this correlation, including the LTV ratio at origination (i.e., variation in initial down payments), and households' post-initial-issuance remortgaging decisions. In the online appendix, we plot the joint distribution of $\widehat{G}$ and $\widehat{H}$, and show that there is substantial variation in the four regions defined by $\widehat{G} \lesseqgtr 0$ and $\widehat{H} \lesseqgtr 0$, which permits identification of their independent impacts on listing decisions.[43]

To assess the extent to which any variation in ℓ attributed to $\widehat{G}$ might be confounded by simultaneous variation in $\widehat{H}$, the top left plot in Figure 5 shows a 3-D representation of ℓ against both $\widehat{G}$ and $\widehat{H}$ in the data, averaged in bins of 3 percentage points. The plot reveals

[41]The online appendix plots the distributions of $\widehat{G}$ and $\widehat{H}$ in the data. Both $\widehat{G}$ and $\widehat{H}$ are winsorized at the 1 percentile point; $\widehat{G}$ is also winsorized at the 99 percentile point. We winsorize $\widehat{G}$ because of several large values of given the substantial time elapsed since the purchase of some properties in the data. We set $\widehat{H}$ to 100% in cases in which households have substantial home equity ($\succeq$ 60%), meaning that we consider households to be essentially unconstrained at high levels of home equity. This is necessary to avoid $\widehat{H}$ levels greater than 1, given the log difference approach that we use to compute it. These filters make no material difference to our results—we confirm that our structural estimates are unaffected by these choices.

[42]This constraint does not change over our sample period, though it must be noted that as mentioned earlier, households can engage in non-mortgage borrowing to effectively increase their LTV, but at substantially higher rates. The online appendix documents the changes in the Danish Mortgage Act over the 2009 to 2016 sample period. While the constraint does not move during this period, there are a few changes in the wording of the act, a change in the maximum maturity of certain categories of loans in February 2012 from 35 to 40 years, and the revision of certain stipulations on the issuance of bonds backed by mortgage loans. None of these materially affect our inferences.

[43]The online appendix also contains a fuller discussion of additional evidence that we uncover which is consistent with households exhibiting aversion to downsizing. We are able to link sale transactions with future purchase transactions for a subset of households, and show that the future purchase is almost always of higher value than the sale.

that ℓ declines in both $\widehat{G}$ and $\widehat{H}$, consistent with the patterns previously identified in the literature. Unusually, given the large administrative dataset that we have access to, the plot captures the variation ℓ along both dimensions simultaneously, and clearly reveals both *independent* and *interactive* variation along both dimensions. To better see the independent variation, the dotted lines on the 3-D surface indicate two cross-sections in the data ($G = 0\%$ and $H = 20\%$), which we also use later for structural estimation. Clearly, the "hockey stick" profile of ℓ along the $\widehat{G}$ dimension survives, controlling for $\widehat{H}$, and there is also a pronounced downward slope in ℓ along the $\widehat{H}$ dimension, controlling for $\widehat{G}$. In terms of the interactive variation, Panel B of Figure 9 plots how the "marginals" of the listing premium vary as we vary the control variable in each case (i.e., $\widehat{H}$ in the left plot and $\widehat{G}$ in the right plot); we discuss these in more detail towards the end of the paper, where we also evaluate the extent to which we can match these relationships using the model.[44]

4.4.2 Concave Demand

Using the underlying data on the time-on-the-market (TOM) that elapses between sale and listing dates, the left plot in Figure 6 calculates the probability of a house sale within six months (this maps to $\alpha(\ell)$ in the model), which we plot on the y-axis, as a function of ℓ on the x-axis.[45] To smooth the average point estimate at each level of ℓ, we use a simple nonlinear function which is well-suited to capturing the shape of $\alpha(\ell)$, namely, the generalized logistic function or GLF (Richards, 1959, Zwietering et al., 1990, Mead, 2017).[46] The solid line corresponds to this set of smoothed point estimates.

The right-hand plot in Figure 6 shows how $\ln P(\ell) - \widehat{\ln P}$, i.e., the "realized premium"

[44]The online appendix reports sale transaction frequencies (to show the degree of bunching) in a similar 3-D fashion. We confirm that regardless of the level of $\widehat{H}$, there is a visible shift of mass from the $\widehat{G} < 0$ domain to the $\widehat{G} > 0$ domain.

[45]Mean (median) TOM in the data is 37 weeks (25 weeks). We pick six months in the computation of $\alpha(\ell)$ to match the median TOM observed in the sample. The online appendix shows the distribution of TOM, which is winsorized at 200 weeks, meaning that we view properties that spend roughly 4 years on the market as essentially retracted.

[46]We describe the GLF in more detail in the online appendix. It is useful for our purposes as it is (i) bounded both from above and below, and it (ii) allows us to easily capture the degree of concavity observed in the data in a convenient way, through a single parameter. In our estimation of the parameters, we restrict the lower bound of the GLF to be equal to zero, to impose that the probability of sale asymptotically converges to 0 for arbitrary high levels of ℓ.

of the final sales price over the hedonic value (which corresponds to the "markup" $\beta(\ell)$ in the model) varies with ℓ. The plot shows that $\beta(\ell)$ rises virtually one-for-one with ℓ when ℓ is low, but flattens out as ℓ rises. The solid line shows a simple polynomial fit of this relationship that we use in the model.

From the two plots, we can see that in Denmark low list prices appear to reduce seller revenue with little corresponding decline in time-on-the-market. This is virtually identical to the patterns detected by Guren (2018) in three U.S. markets, which he terms "demand concavity".[47]

This evidence of demand concavity serves as a confound for estimating λ, as described earlier. This is because the model predicts two possible and distinct sources of the differential slopes of ℓ^* across gains and losses. One is that in the presence of loss aversion (i.e., $\lambda > 0$), there are kinks in ℓ^* around $\widehat{G} = 0$, which can be smoothed into a differential slope by variation in θ. The second is buyer sensitivity to ℓ, i.e. the degree of demand concavity $\alpha(\ell)$. The top panel of Figure 6 illustrates this second mechanism in the model, which predicts that sellers set a steeper ℓ^* slope when $\widehat{G} < 0$ in markets where $\alpha(\ell)$ demand is *less* steeply sloped and vice versa. This predicts a tight correlation between the slope of $\alpha(\ell)$ and the slope of ℓ when $\widehat{G} < 0$, which cannot be seen in Figure 6, which is estimated using the entire dataset. To estimate the impact of demand concavity on the shape of the listing premium "hockey stick," we therefore exploit regional variation across sub-markets of the Danish housing market.

To illustrate the predicted correlation between the shape of the listing premium "hockey stick" and the degree of demand concavity (i.e., the shape of $\alpha(\ell)$) in the data, we separately estimate the slope of ℓ in the domain $\widehat{G} < 0$, as well as separate $\alpha(\ell)$ functions (in particular, the slope of $\alpha(\ell)$ when $\ell \geq 0$) in different local housing markets, namely, different municipalities of Denmark.[48]

[47]These plots also show that Danish sellers who set high ℓ suffer longer TOM, but ultimately achieve higher prices (i.e., high realized premia) on their house sales, confirming the original finding of Genesove and Mayer (2001), who analyze the Boston housing market between 1990 and 1997.

[48]Municipalities are a natural local market unit—there are 98 in Denmark, each of around 60,000 inhabitants, and with roughly 1,800 listings on average. We also re-do this exercise using shires, which are a smaller geographical delineation covering 80 listings on average as a cross-check.

The bottom panel of Figure 7 shows results when we sort municipalities by their estimated demand concavity (i.e., the slope of $\alpha(\ell)$ when $\ell \geq 0$). The right-hand panel of the plot illustrates that there is indeed substantial variation in demand concavity across municipalities, showing municipalities in the top and bottom 5% of estimated demand concavity. The slope for municipalities with strong demand concavity (top 5%) lies between -1.4 and -1.1, while the slope for municipalities with weak demand concavity (bottom 5%) lies between -0.1 and -0.3. The left-hand plot in Figure 7 Panel A shows the corresponding figure for the relationship between $\hat{\ell}$ and $\widehat{G}$ for these municipalities. Indeed, as the model predicts, markets with strong demand concavity exhibit a substantially weaker slope of ℓ in the domain $\widehat{G} < 0$ (-0.1 to -0.4) than markets with weak demand concavity (-0.5 to -0.9).[49] Towards the end of the paper, we describe a validation analysis that we undertake to confirm the model-predicted mechanism in the data using instruments for demand concavity.

4.5 Robustness

4.5.1 Time-series Variation

While it is reassuring that $\widehat{G}$ and $\widehat{H}$ exhibit independent variation in the data, it could well be the case that this variation is confined to one particular part of the sample period, i.e., driven by time-variation in aggregate Danish house prices. To check this, in the online appendix we plot the shares of the data in each of four groups of properties defined by $\widehat{G} \lesseqgtr 0$ and $\widehat{H} \lesseqgtr 0$, in each of the years in our sample. We find that aggregate price variation does shift the relative shares in each group across years, with price rises increasing the fraction of unconstrained winners ($\widehat{G} > 0$ and $\widehat{H} > 0$) relative to losing and constrained groups. However, the relative shares of all four groups are substantial and fairly stable over

[49] For the purposes of our current investigation, we focus on the slope differentials, and to show these, Figure 7 normalizes sub-markets to have the same level of the listing premium. We also observe important differences between the *levels* of $\alpha(\ell)$ across these markets i.e., there are both "hot" and "cold" municipalities à la Ngai and Tenreyro (2014). Un-normalized plots in the online appendix reveal that the *level* of ℓ is lower when the level of $\alpha(\hat{\ell})$ is higher and vice versa; and consistent with Ngai and Tenreyro (2014), the levels of $\alpha(\ell)$ and $P(\ell)$ are strongly positively correlated across sub-markets.

the sample period, alleviating concerns that different groups simply come from different time periods, i.e., the plots is reassuring that identification of any effects is likely to arise mainly from the cross-section rather than the time-series. We also verify that the inclusion of cohort and cohort-cross-municipality fixed effects in the hedonic model does not affect our inferences materially.

4.5.2 Bunching: Round Numbers and Holding Periods

In the online appendix, we verify that the bunching patterns documented earlier are robust to commonly expressed concerns in this literature (e.g., Kleven 2016, Rees-Jones 2018). We find that the spike in sales volumes at $G = 0$ and the patterns of excess mass relative to the counterfactual do not appear to be driven by bunching at round numbers, as they remain striking and visible when we exclude sales at prices ending in multiples of $10,000$, $50,000$, $100,000$, and $500,000$ DKK, which (cumulatively) affect roughly 20%, 17%, 5%, and 2% of all observations, respectively. We also show that these bunching patterns are robust when we split the sample into five groups (< 3, $3-6$, $6-9$, $9-12$, > 12 years) based on the time between sale and purchase, i.e., the holding period of the property. Except for the sub-sample with the longest holding period (> 12 years, 20% of the data), we find strong evidence of bunching. Finally, we also find strong evidence of bunching in all cases when we split the sample into quintiles based on the level of R, with quintile cutoffs ranging from around $658,000$ DKK to 1.9MM DKK. Together, these checks assuage concerns that bunching could result from differences in the underlying characteristics of properties—for instance these tests suggest that it is implausible that bunching results from a combination of small properties with shorter holding periods clustering around $G = 0$, and larger properties with longer holding periods showing up at values of $G > 0$.

4.5.3 Unobserved Quality

An important and often-repeated concern in the literature is that the relationships that we observe between ℓ and $\widehat{G}$ (and indeed $\alpha(\ell)$ and ℓ), can be spuriously affected by measurement error in the underlying model for $\widehat{P}$. In particular, if properties with $\widehat{G} < 0$ are deemed to be such as a result of underestimated $\widehat{P}$, we would also see higher listing premia for such properties, resulting in the hockey-stick shape that we observe. Moreover, such an issue could also upwardly bias the true (decreasing) relationship between the probability of a quick sale and ℓ, especially when $\ell > 0$, as houses with mismeasured high listing premia would be expected to transact faster.

We assess the robustness of our results to these concerns in a number of ways, all of which we describe in detail in the online appendix. First, we show that the relationships between ℓ, $\widehat{G}$, and $\alpha(\ell)$ are robust to a battery of changes to the underlying model used to estimate $\widehat{P}$. We do so in several ways. We employ a repeat sales model to difference out time-invariant unobserved property quality; we instrument variation in $\widehat{P}$ using regional house price indices; we control for demographics, financial wealth, and further interactions in the hedonic model using granular data that have previously been unutilized in this manner, and which are potentially informative about the seller's response to earlier under- or over-payment on the property; we use the external tax assessor value of the property instead of our estimated hedonic model; and finally, we verify that our inferences hold even when we use out-of-sample estimated hedonic coefficients.[50]

Second, we implement the bounding approach proposed in Genesove and Mayer (2001) to account for unobserved quality, and confirm that our inferences are robust to doing so.

Third, while the tests just described focus on showing robustness of the magnitudes of the nonlinear relationships observed in the data between ℓ, $\widehat{G}$, and $\alpha(\ell)$, we also document evidence in line with the key predictions from the model. That is, we are able to demonstrate that the observed nonlinearities are in fact discontinuous and sharp around the respective thresholds of $\widehat{G} < 0$ and $\ell > 0$, using a regression kink design (RKD) originally suggested by Card et al. 2015b and implemented e.g., by Landais, 2015, Nielsen et al. 2010, and

[50]This last variation helps to assuage concerns of overfitting or mechanical correlation arising from our hedonic model being estimated using the sample of sold listings. The model fits relatively precisely out of sample, with R^2's ranging between 0.80 to 0.88 when predicting between 1% to 50% of the data out-of-sample, and the patterns in the relationships between ℓ, $\widehat{G}$, and $\alpha(\ell)$ are robust to using the oos coefficient estimates.

Card et al. 2015a. In line with the identifying assumptions of this research design, we also show that property-and household-specific observable characteristics are smooth around the respective thresholds.

5 Structural Estimation

5.1 Moments in the Model

To match the data moments inside the model, we make a few assumptions. First, we simply use the estimated demand concavity $\alpha(\ell)$ and $P(\ell)$ shown in Figure 6 as two of these inputs. Second, we set $\gamma = 20\%$ according to Danish law. Third, we normalize all quantities in the model, setting the property's fundamental value $\widehat{P} = 1$ and we set the outside option $\underline{u} = \widehat{P}$. Fourth, we define the variables $\widehat{G} = \widehat{P} - R$ and $\widehat{H} = \widehat{P} - M$ as the model equivalents of potential gains and home equity in the data.

Next, consider the set of parameters from the model:

$$\mathbf{x} = \begin{bmatrix} \eta, & \lambda, & \delta, & \mu, & \theta_{\min}, & \theta_{\max}, & \varphi \end{bmatrix}'. \tag{8}$$

To obtain policy functions of state variables and parameters, we solve the model numerically, inputting grids of $\widehat{G}$ and $\widehat{H}$, and yielding:

$$\left[s^*(\widehat{G}, \widehat{H}, \theta, \mathbf{x}), \ell^*(\widehat{G}, \widehat{H}, \theta, \mathbf{x})\right] = \arg \max_{s \in \{0,1\}} \left\{(s) \max_{\ell} \left\{EU(\ell, \widehat{G}, \widehat{H}, \theta, \mathbf{x})\right\} + (1-s)\underline{u}\right\}. \tag{9}$$

We then compute aggregates, i.e., averages in the population of listing probabilities, and average listing premia which account for the extensive margin decision:

$$S^*(\widehat{G}, \widehat{H}, \mathbf{x}) = \int s^*(\widehat{G}, \widehat{H}, \theta, \mathbf{x}) d\theta, \tag{10}$$

$$\mathscr{L}^*(\widehat{G}, \widehat{H}, \mathbf{x}) = \int_{s^*=1} \ell^*(\widehat{G}, \widehat{H}, \theta, \mathbf{x}) d\theta. \tag{11}$$

These functions then allow us to compute the set of seven model-implied moments

$\mathbf{M_m}(\mathbf{x})^{7\times1}$ corresponding to the moments in the data $\mathbf{M_d}^{7\times1}$ described above.

The first moment is the average listing premium $\mathscr{L}^*(\widehat{G}=0\%, \widehat{H}=20\%, \mathbf{x})$. The second is a slope from regressing $\mathscr{L}^*(\widehat{G}, \widehat{H}=20\%, \mathbf{x})$ on the grid of $\widehat{G}$ for $\widehat{G}<0$. The third is a slope from regressing $\mathscr{L}^*(\widehat{G}=0\%, \widehat{H}, \mathbf{x})$ on the grid of $\widehat{H}$ for $\widehat{H}<20\%$.

We next propose a simple procedure to approximate the regional correlation moments (i.e., the relationship between variation in demand concavity and the slope of the listing premium) inside the model. Let $\kappa_{\widehat{G}<0}$ be the slope from a regression of $\mathscr{L}^*(\widehat{G}, \widehat{H}=20\%, \mathbf{x})$ on the grid of $\widehat{G}$ for $\widehat{G}<0$, and $\kappa_{\widehat{G}\geq0}$ the analogous slope for $\widehat{G}\geq0$ ($\kappa_{\widehat{G}<0}$ and $\kappa_{\widehat{G}\geq0}$ simply capture the slopes of the listing premium above and below potential gains of zero). Now consider a change $\tilde{\delta}$ in demand concavity. We re-compute each of the κ slopes for $\delta-\frac{\tilde{\delta}}{2}$ and $\delta+\frac{\tilde{\delta}}{2}$, which is a first-order approximation of the degree to which a change in concave demand "passes through" to the slopes of $\mathscr{L}^*$ above and below $\widehat{G}=0\%$. The fourth and fifth moments inside the model are then given by $\frac{\kappa^+_{\widehat{G}<0}-\kappa^-_{\widehat{G}<0}}{\tilde{\delta}}$ and $\frac{\kappa^+_{\widehat{G}\geq0}-\kappa^-_{\widehat{G}\geq0}}{\tilde{\delta}}$.

The sixth moment measures bunching of transactions around realized gains of zero. To calculate this measure, we begin with a randomly generated sample of $N=1,000$ draws of $\widehat{G}$ from a uniform distribution with limits $(-50\%, +50\%)$. For each observation in the sample, we obtain the optimal aggregate listing premium $\mathscr{L}^*$ for a level of home equity equal to 20% and the average level of the moving shock, and calculate realized gains as $G=P(\mathscr{L}^*)-R$. In addition, we model the likelihood that the transaction goes through by drawing a random number ϵ from a uniform distribution and including the observation in the final sample of transactions if $\epsilon<\alpha(\mathscr{L}^*)$. The measure of bunching is then given by the relative density of transactions in the positive vs. the negative domain, in the interval $[-5\%, +5\%]$.[51]

Finally, the seventh moment is given by the slope from a regression of $S^*(\widehat{G}, \widehat{H}=20\%, \mathbf{x})$ on the grid of $\widehat{G}$, to match the corresponding extensive margin moment in the data.

[51] We choose this slightly wider interval than in the data to avoid situations in which our results may be influenced by the grid sizes.

5.2 Classical Minimum Distance Estimation

From the moments in the data and in the model, we calculate:

$$g(\mathbf{x}) = M_m(\mathbf{x}) - M_d.$$

Since the system is exactly identified, i.e., seven moments and seven parameters, we can estimate the structural parameters $\widehat{\mathbf{x}}$ simply as:

$$\widehat{\mathbf{x}} = \arg\min_{\mathbf{x}} g(\mathbf{x})' g(\mathbf{x}).$$

The asymptotic variance of the parameters is given by:

$$\overline{avar}(\widehat{\mathbf{x}}) = \left[\frac{\partial g(\mathbf{x})}{\partial \mathbf{x}} \overline{W} \frac{\partial g(\mathbf{x})}{\partial \mathbf{x}'}\right]^{-1},$$

where we set $\overline{W}$ to the inverse of the normalized covariance matrix of moments $\mathbf{x}$. We consider both a simple (diagonal) case: $\overline{W}_{ii} = (\sigma_i^2/N_i)^{-1}$, as well as the (shire-clustered) bootstrap full covariance matrix. Finally, we make inferences about the parameter estimates using the asymptotic relationship:

$$\widehat{\mathbf{x}} \to^d N(\mathbf{x}, \overline{avar}(\widehat{\mathbf{x}})).$$

5.3 Parameter Estimates

Table 2 shows the estimated parameters and associated standard errors. The data favor a model of reference dependence with $\eta = 0.948$ with a degree of loss aversion $\lambda = 1.576$. This λ estimate is lower than that commonly considered in the early literature, which lies between 2 and 2.5 (e.g., Kahneman et al. 1990, Tversky and Kahneman, 1992), but is closer to estimates reported in more recent literature (e.g., Imas et al. 2016 finds a value of $\lambda = 1.59$).[52]

[52] Given how close the estimated η is to 1, we re-estimated a restricted version of the model where $\eta = 1$. Further details are discussed in the online appendix. We obtained similar estimates of $\lambda = 1.522$ (*s.e.* 0.479),

The parameter $\mu = 1.060$ best matches the average $\hat{\ell}$ slope with respect to $\widehat{H}$, i.e., there is an 106 bp penalty (expressed as a fraction of the mortgage amount) for every percent that H drops below $\gamma = 20\%$. This parameter can be contrasted with an average rate increase of roughly 50 bp on the whole loan if the household were to borrow an additional 10% in the unsecured Danish lending market.[53] The relatively larger number suggests that households in Denmark faced financial constraints preventing them from borrowing. In support of this, we find that the median household in our sample has *negative* net liquid financial wealth of roughly -9%, i.e., their unsecured debt is greater than their liquid financial assets (stocks, bonds, cash) by this amount.

We find that $\delta = -0.097$, which corresponds to a perceived relative reduction of the probability of sale of 9.7%, for a household listing at $\ell = 10\%$, and that the distribution $\theta \sim$Uniform$(\theta_{\min}, \theta_{\max})$ has parameters $\theta_{\min} = 0.217$ and $\theta_s = 1.005$. These "moving shocks" correspond to the present discounted value of future benefits from successfully selling and/or moving, and are on the order of 21.7% of the hedonic price for a household at the minimum of the distribution, and approximately equal to the entire hedonic value for a household at the maximum of the distribution. Finally, we find that the estimated "all-in" cost of listing is 3.7% of the hedonic value of the house.

Andrews et al (2017) argue that in method-of-moments estimation of the type that we use, it is often useful to understand the mapping from moments to estimated parameters. In the online appendix we propose a simple and less formal application of this idea, describing how each moment varies when we re-compute the model-implied moments varying each of the structural parameters by two standard deviations. This also provides useful intuition on the sources of identification in the data for each of the model's parameters. We also evaluate the importance of correctly modelling demand concavity. We do so by adopting a naïve approach to estimation that eschews this important feature and simply assumes that

$\mu = 1.158$ (*s.e.* 0.218), $\delta = -0.093$ (*s.e.* 0.0183), $\theta_{\min} = 0.235$ (*s.e.* 0.148), $\theta_{\max} = 1.052$ (*s.e.* 0.131) and $\varphi = 0.039$ (*s.e.* 0.025).

[53] Households in this market face between 200-500 basis points increases in interest rates for every percentage point of borrowing in this market between 80 and 95 LTV over our sample period. Taking 450 bp as the point estimate within this range, at an 80% LTV an additional ten percent borrowing adds roughly 50 bp to the overall loan.

demand is linear. To do so, we preserve the $P(\ell)$ function, but simply estimate a linear $\alpha(\ell)$ function, and re-estimate the parameters (apart from δ) under this assumption. We find that in the case of this restricted model, we estimate $\eta = 0.750$ with a degree of loss aversion $\lambda = 3.285$, a radical departure from the more realistic estimates that we extract when demand is permitted to be concave.

6 Validation and Open Questions

6.1 Interactions

The top panel of Figure 9 compares the 3-dimensional patterns of optimal listing premia in the data (left-hand plot) and the model (right-hand plot). The model matches the pronounced increase in $\hat{\ell}$ for $G < 0$, and the similar increase in $\hat{\ell}$ when $\widehat{H}$ declines. A striking feature of this plot is that it seems to indicate that the position of any reference point is not uniquely determined by $\widehat{G}$ or $\widehat{H}$ alone. As we briefly mentioned earlier, there is considerable variation in the slope of the relationship between $\hat{\ell}$ and both $\widehat{G}$ and $\widehat{H}$ that depends on the level of the other variable. Put differently, both in the data and in the model, it appears as if the effects of losses and constraints interact with one another, and that the factors affecting household behavior are neither one nor the other variable in isolation.

The bottom panel of Figure 9 explores these interaction effects in more detail. We plot selected cross-sections of the listing premium surface in the data, using a smooth function of the bins for ease of visualization as dashed lines, alongside their model equivalents as solid lines.[54] The left-hand plot in the bottom panel shows that there is a change in the slope of the ℓ - $\widehat{G}$ relationship as $\widehat{H}$ varies, and the right-hand plot, that there seems to be a change in the inflection point in the ℓ - $\widehat{H}$ relationship as $\widehat{G}$ varies. Note that the average level of ℓ in the data declines substantially as households become less constrained, and increases substantially as households become more constrained—this is simply the unconditional relationship between ℓ and $\widehat{H}$, seen in a different way in the left-hand plot. What is more

[54] We simply use the GLF function for this purpose. The online appendix shows a plot of the actual bins in the data alongside the model-implied listing premia.

interesting is that controlling for this change in level, the *slope* of ℓ as a function of $\widehat{G}$ is affected by the level of $\widehat{H}$. The important new fact is that down-payment-unconstrained households exhibit seemingly greater levels of reference dependence along the gain/loss dimension, exhibiting a pronounced increase in the slope to the left of $\widehat{G} = 0$. In contrast, down-payment constrained households exhibit a flatter ℓ along the $\widehat{G}$ dimension. The right-hand plot in the bottom panel of the figure shows the ℓ - $\widehat{H}$ relationship, where again, the level differences reflect the ℓ - $\widehat{G}$ relationship. Another interesting fact emerges—along the $\widehat{H}$ dimension, while the slope around the threshold does not change, *the position of the kink* in ℓ *increases* with the level of past experienced gains.

These new facts appear to require a more intricate model of preferences and/or constraints than the literature has thus far proposed, which cannot be rationalized by our canonical model, which captures many of the forces thus far proposed in the literature. We briefly speculate on the possible types of models that may rationalize these findings here, with a view towards motivating theoretical work on a broader class of preference and constraint specifications.

One possible rationalization of the variation in the ℓ - $\widehat{G}$ relationship with $\widehat{H}$ is that the luxury of being unconstrained appears to cause more psychological motivations such as loss aversion to come to the fore. Put differently, unconstrained households seem constrained by their loss aversion à la Genesove and Mayer (2001), while constrained households respond to their real constraints by engaging in "fishing" behavior à la Stein (1995). It may also be that this finding can be rationalized by a more complex specification of reference points such as expectations-dependent reference points (e.g., Köszegi and Rabin, 2006, 2007, and Crawford and Meng, 2011).

Turning to the change in the position of the kink in the ℓ - $\widehat{H}$ relationship as $\widehat{G}$ varies, it appears as if a household's propensity to engage in "fishing" behavior kicks in at a level of $\widehat{H}$ that is strongly influenced by their expected $\widehat{G}$. One possible rationalization of this is that households facing nominal losses feel constrained at levels of home equity (i.e., $H = 20\%$) that would force them to downsize, while those expecting nominal gains may have in mind a larger "reference" level of housing into which they would like to upsize (or indeed, a larger fraction of home equity in the next house). To achieve this larger reference level of housing, they begin "fishing" at levels of $H > 20\%$ in hopes of achieving the higher down payment on the new, larger house. To provide suggestive evidence on this story, in the online appendix we focus on a sample of $14,440$ households for which we can find two subsequent housing transactions and mortgage down payment data. For this limited subsample, we show a binned scatter plot of the ℓ on the subsequently sold listing against the realized down payment on the subsequent house, controlling for the level of $\widehat{H}$ on the subsequently sold listing. We find evidence that the down payment on the new house is correlated with ℓ, which, given our evidence of $\widehat{G}$ predicting ℓ, is consistent with the idea that households shifting their reference level of housing on the basis of expected gains.

6.2 Demand Concavity, Housing Stock Homogeneity, and Listing Premia

Earlier, we documented how regional variation in demand concavity correlates with regional variation in the shape of the listing premium schedule. This relationship could be driven by a number of different underlying forces. For instance, demand may respond to primitive drivers of supply rather than the other way around—i.e., some markets may be populated by more loss-averse sellers, and buyer sensitivity to ℓ^* might simply accommodate this regional variation in preferences. Another possibility is that this regional relationship simply captures the different incidence of common shocks to demand and market quality.

Our model is partial equilibrium, and describes a different underlying mechanism for this correlation, namely, that sellers are optimizing in the presence of the constraints imposed by demand concavity. In order to understand whether the left-hand plot of Panel B of Figure 7 is potentially consistent with sellers responding to such incentives, we implement an instrumental variables (IV) approach. Our IV approach is driven by the intuition that the degree of demand concavity is related to the ease of value estimation and hence price comparison for buyers. Intuitively, a more homogeneous "cookie-cutter" housing stock can make valuation more transparent, and should therefore increase buyers' sensitivity to ℓ. That is, this intuition predicts that markets with high homogeneity should exhibit more pronounced demand concavity.

Our main instrument is the share of apartments and row houses listed in a given sub-market. Row houses in Denmark are houses of similar or uniform design joined by common walls, and apartments have less scope for unobserved characteristics such as garden sheds and annexes than regular detached houses.[55] As an alternative, we also use the distance (computed by taking the shire-level distance to the closest of the four cities, averaged over all shires in a given municipality) to the four largest cities in Denmark (Copenhagen, Aarhus, Odense, and Aalborg) as a measure of how rural a given market is, and how far away from cities people live on average. This alternative relies on the possibility that homogeneous housing units are more likely to be built in suburbs or in cities, rather than in the countryside.

In the case of both instruments, the identifying assumption is that these measures of homogeneity of the housing stock only affect the slope of $\hat{\ell}$ with respect to $\widehat{G}$ through their effect on $\alpha(\hat{\ell})$. To account for cross-market differences in model-predicted demand-side factors affecting the slope of ℓ with respect to $\widehat{G}$ and $\widehat{H}$, we also include specifications which control for the average age, education length, financial assets, and income of sellers in a given sub-market.

Figure 7 on the right-hand side of Panel B shows strong evidence of the "first-stage" correlation, i.e., demand concavity on the y-axis against homogeneity measured by the share of apartments and row-houses in a given municipality on the x-axis, with each dot representing a municipality (more negative values of demand concavity mean a sharper slope of $\alpha(\ell)$ to the right of $\ell = 0$). Table 3 reports the results of the more formal IV exercise. Column 1 shows the simple OLS relationship between the slope of ℓ for $\widehat{G} < 0$ on demand concavity slope (slope of $\alpha(\ell)$ for $\ell \geq 0$) across municipalities,[56] with a baseline

[55] In the online appendix, we show pictures of typical row houses in Denmark.

[56] Municipalities are required to have at least 30 observations where $\widehat{G} < 0$, leaving 95 out of 98 municipalities, but results are robust to keeping all municipalities.

level of −0.407. Column 2 uses the apartment-and row-house share as an instrument for demand concavity, and the just identified two-stage least squares (2SLS) specification yields a coefficient estimate of −0.520. With both instruments (i.e., including the distance to the largest cities as well), the overidentified 2SLS specification gives a result of −0.504 without, and −0.346 with controls for average household characteristics in the municipality. The first-stage F-statistics are between 17 and 25, assuaging weak-instrument concerns (Stock and Yogo, 2002) and we cannot reject the null of the Hansen overidentification test of a correctly specified model and exogenous instruments at conventional significance levels.[57] These results appear to validate the mechanism that we propose in the model.

7 Conclusion

We structurally estimate a new model of house listing decisions on comprehensive Danish housing market data, and acquire new estimates of key behavioral parameters and household constraints from this high-stakes household decision. Underlying preferences seem well characterized by reference dependent around the nominal purchase price plus modest loss aversion, and there is also evidence of the important role of down-payment constraints on household behavior.

The model cannot completely match some new facts which we identify in the data, which we view as a new target for behavioral economics theory. Nominal losses and down-payment constraints interact with one another, in the sense that reference-dependent behavior is less evident when households are facing more severe constraints, and most pronounced for unconstrained households. Home equity constraints also appear to loom larger for households facing nominal losses. However, for households facing nominal gains, there is evidence consistent with an upward shift in the point at which they feel constrained. This could be explained by households resetting their desired size or quality of housing upwards in response to experienced gains.

[57] These results are robust to using a logit model, different cutoffs ($\ell \geq 5$, 10, 15%) for the demand concavity estimation, cuts of the data such as excluding the largest cities Copenhagen and Arhus, and regressions at the shire level. These robustness checks are all available in the online appendix.

In micro terms, this interaction between reference dependence and constraints could have implications for the way we model behavior. We tend to assume that agents optimize their (potentially behavioral) preferences subject to constraints, and in numerous models, agents may also wish to impose constraints on themselves to "meta-optimize" (Gul and Pesendorfer, 2001, 2004, Fudenberg and Levine, 2005, Ashraf et al. 2006, DellaVigna and Malmendier 2006). However, if constraints affect the incidence of behavioral biases, or indeed, if being in a zone that is more prone to bias affects the response to constraints, our models must of necessity become more complicated to accommodate such behavior. From a more macro perspective, reference dependence appears important for understanding aggregate housing market dynamics. The housing price-volume correlation tends to fluctuate, and especially during housing market downturns, prices and liquidity can move in lockstep. This has important implications for labor mobility, which responds strongly to housing "lock" (Ferreira et al., 2012, Schulhofer-Wohl, 2012). Interaction effects such as the effect of expected losses on the household response to constraints could also help to make sense of the seemingly extreme reactions of housing markets to apparently small changes in underlying prices, and help to inform mortgage market policy (Campbell, 2012, Piskorski and Seru, 2018).

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Figure 1

Reference dependence and loss aversion

The figure illustrates how each specification of utility function is reflected in the sellers' optimal choice of listing premia. We plot a stylized version of listing premium profiles, for the case in which demand functions $\alpha(\ell)$ and $\beta(\ell)$ are linear and the household is not facing financing constraints. In the online appendix, we describe and solve an analytical version of this model.

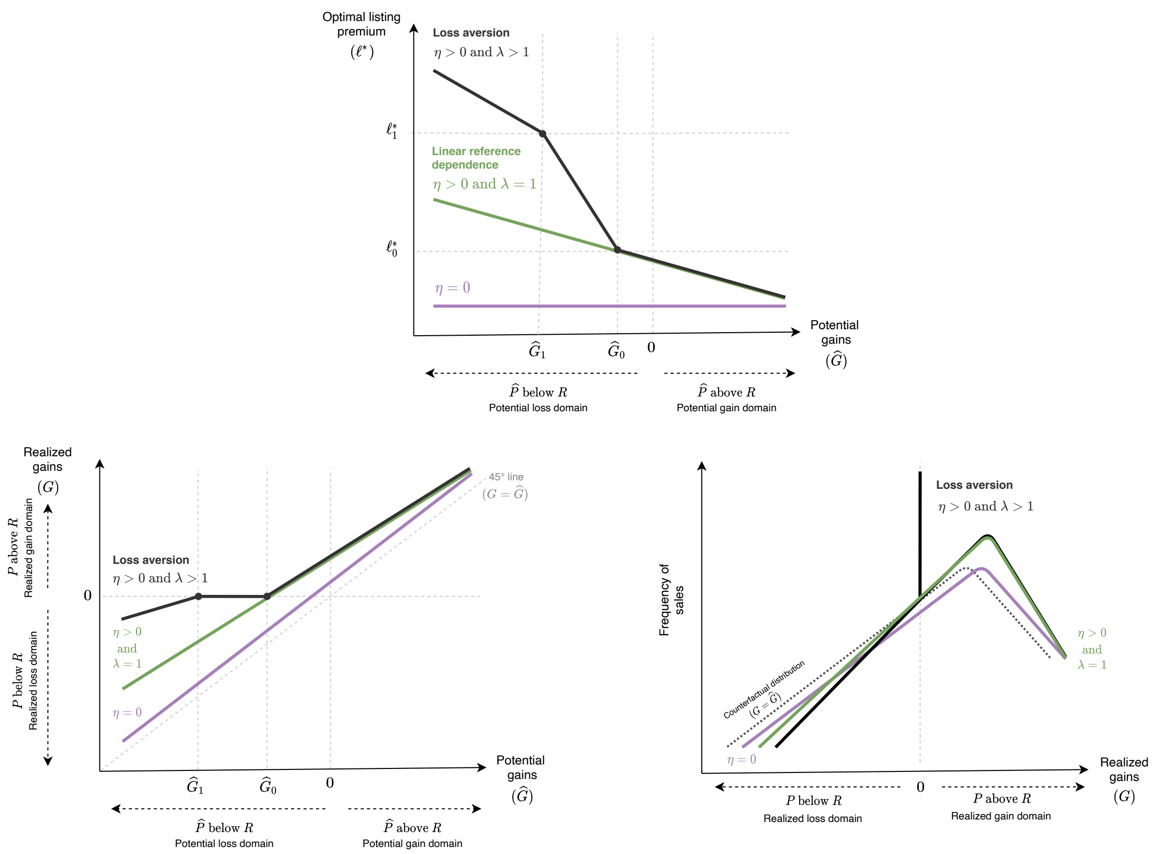


Figure 2
Concave demand

This figure illustrates the link between concave demand and the choice of optimal listing premia. We plot a stylized listing profile resulting from a case of pure reference dependence with no loss aversion ($\eta > 0$ and $\lambda = 1$). Since the probability of sale does not respond to listing premia set below a certain level $\underline{\ell}$, it is rational for sellers to not respond to the exact magnitude of the expected gain. A steeper slope of demand translates into a general flattening out of the listing premium profile.

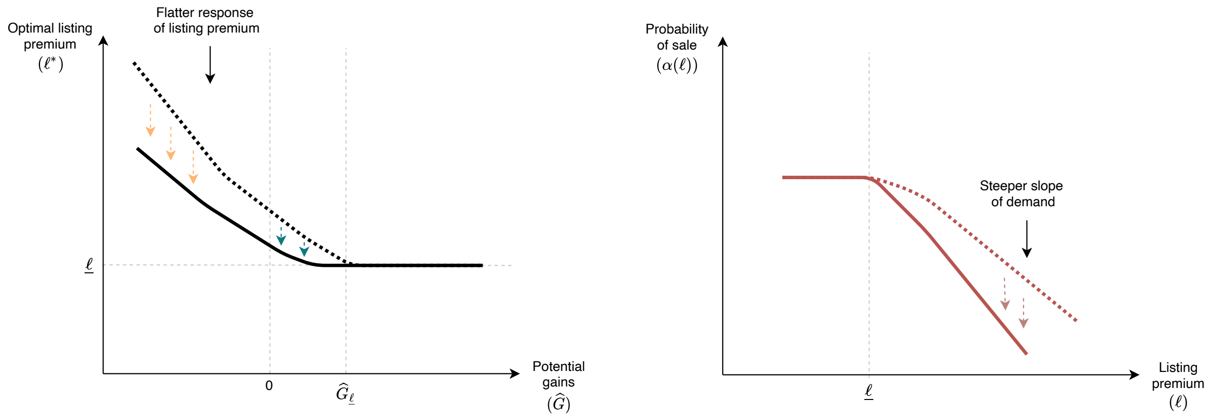


Figure 3
Listing premia and potential gains

The figure reports binned average values (in 1 percentage point steps) for the listing premium (ℓ) for different levels of potential gains ($\widehat{G}$). The green line corresponds to a polynomial of order three, fitted in the positive domain of potential gains. The red line corresponds to an equivalent polynomial fit in the potential loss domain.

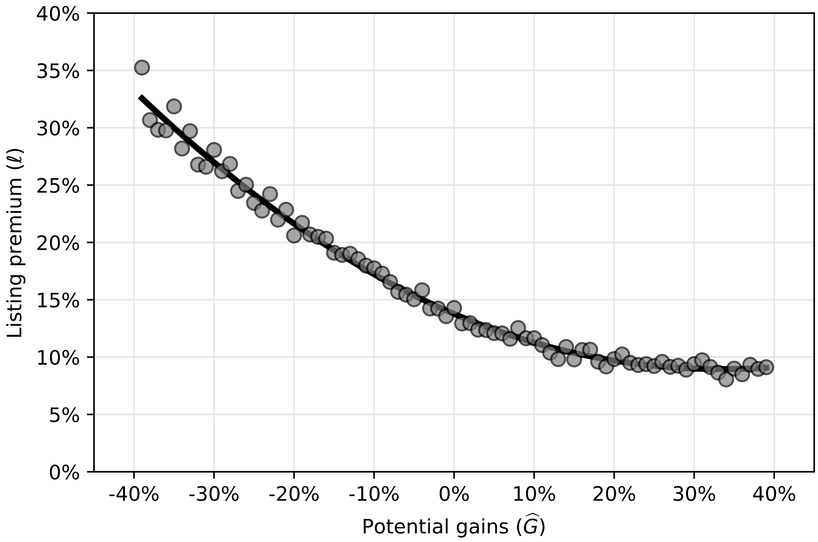


Figure 4
Bunching around realized gains of zero

The figure reports binned frequencies of observations (in 1 percentage point steps) for different levels of realized gains (G). The dotted line shows the counterfactual corresponding to the distribution of potential gains ($\widehat{G}$) in the sample of realized sales.

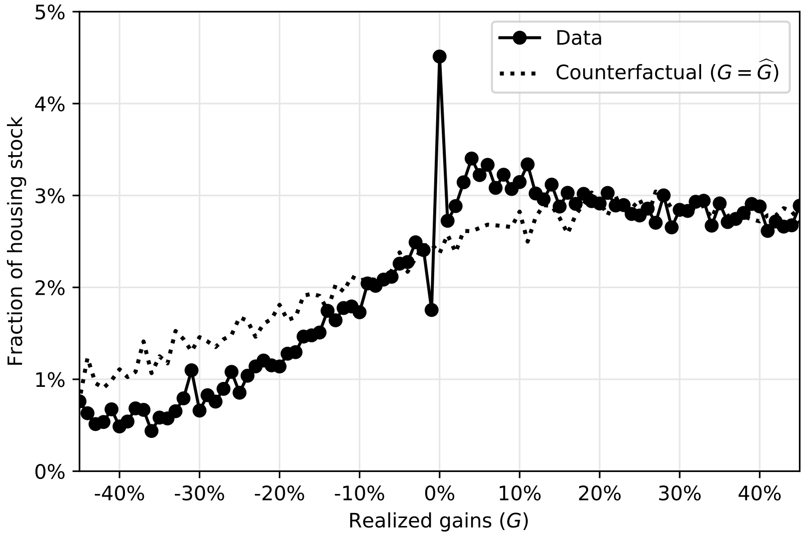


Figure 5

Gains vs. home equity

The figure reports binned average values (in 3% steps) for the listing premium (ℓ) along both levels of potential gains and home equity, and the observed frequency of sales along levels of realized gains and home equity. The dotted lines show the binned values for two cross-sections, where we condition on a home equity level of 20%, and a level of gains of 0%, respectively. We use these two representative cross-sections to generate the empirical moments used in structural estimation.

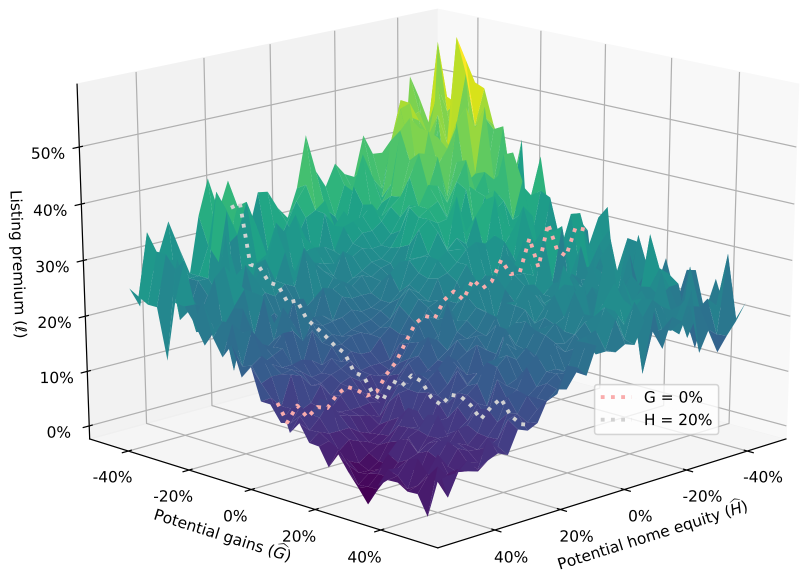


Figure 6

Concave demand in the data

The left-hand side of the figure reports the average probability of sale within six months $\alpha(\ell)$ across 1 percentage point bins of the listing premium in the sample. The solid line indicates fitted valued corresponding to a generalized logistic function (GLF). The right-hand side of the figure shows the average realized premium $\beta(\ell)$ across bins of the listing premium. The solid line indicates fitted values corresponding to a polynomial of order three.

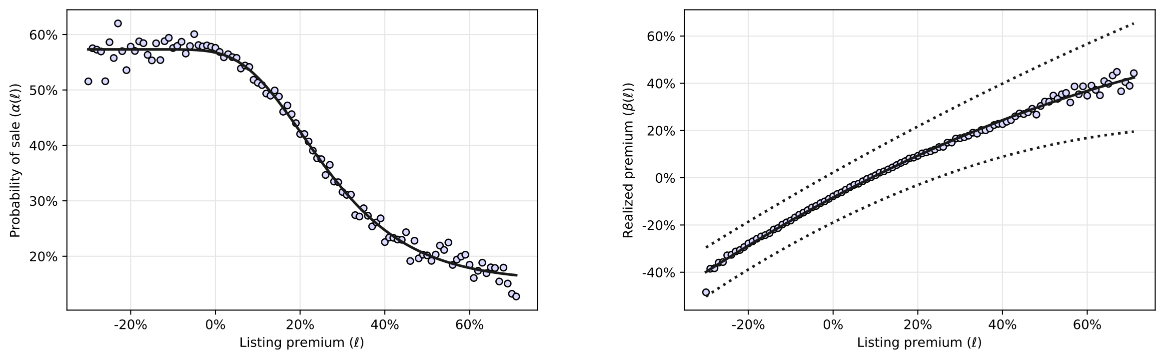
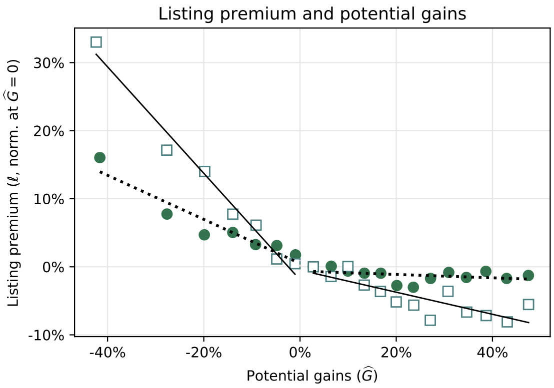


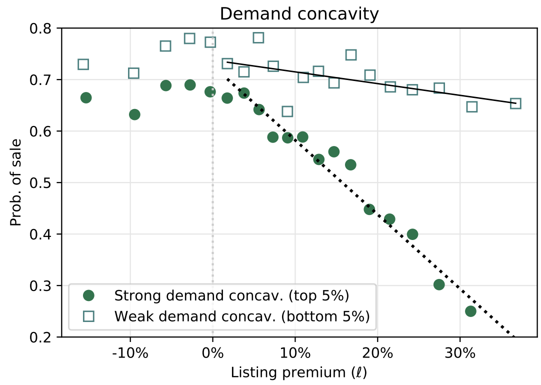
Figure 7

Listing premium-gain slope and demand concavity

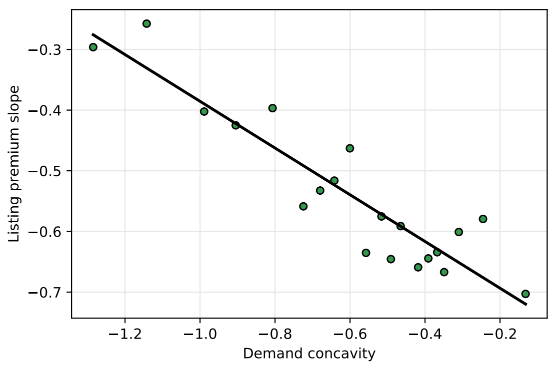
Panel A shows the listing premium over gains (left-hand side) and demand concavity (right-hand side) patterns. We sort municipalities by the estimated demand concavity, using municipalities in the top and bottom 5% of observations. Demand concavity is estimated as the slope coefficient of the effect of the listing premium on the probability of sale within six months, for $\ell > 0$. For better illustration of the main effect, we adjust the quantities measured to have the same level at $G = 0\%$ and $\ell = 0\%$ respectively. The left-hand side of Panel B shows the correlation between the estimated listing premium slope and demand concavity across municipalities using a binned scatter plot with equal-sized bins. The right-hand side of Panel B shows a binned scatter plot of the correlation between the main instrument, the share of listed apartments and row houses in a given municipality, and demand concavity in a binned scatter plot with equal-sized bins.

Panel A





Panel B



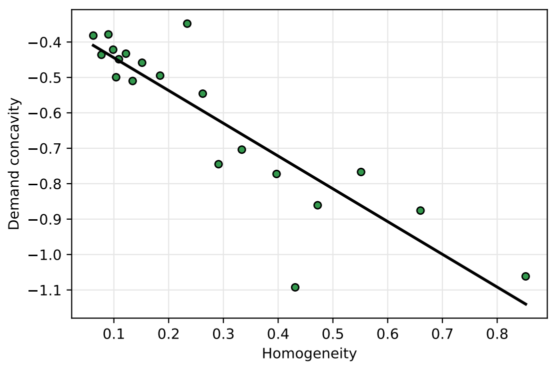


Figure 8

Extensive margin

The figure reports the average yearly probability of listing a property for sale. We first calculate the potential gain level for each unit in the stock of properties in Denmark, for each year covered by our sample of listings. We then divide the number of properties which have been listed for sale by the number of total property × year observations in the stock of properties, for each 1 percentage point bin of potential gains.

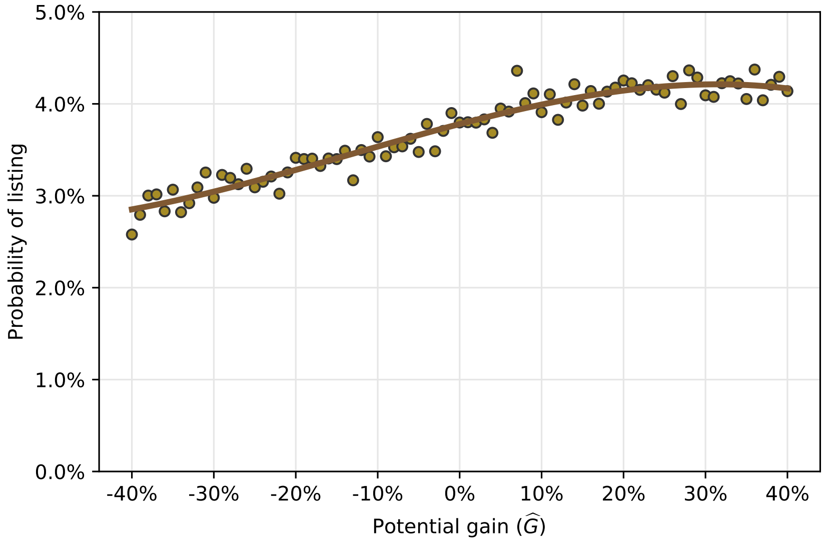
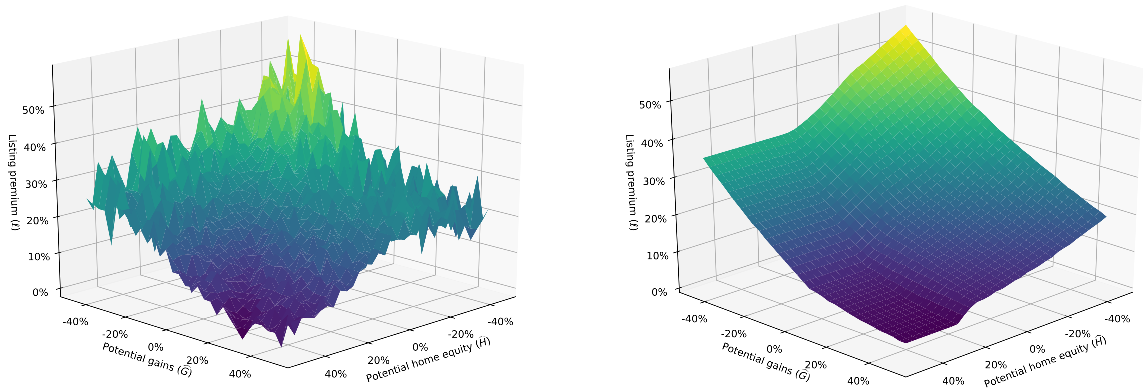


Figure 9
Model fit

Panel A reports listing premia by potential gains and home equity, both in the data and in the model. We use the set of seven estimated parameters to evaluate average quantities in the model, accounting for the extensive margin decision of whether to list the property for sale or not. Panel B illustrates the model fit for conditional listing premia profiles, conditioning on different levels of potential gains and home equity. Dotted lines indicate observations in the data (for which we report fitted values using generalized logistic functions) and solid lines their model-implied counterparts.

Panel A



Panel B

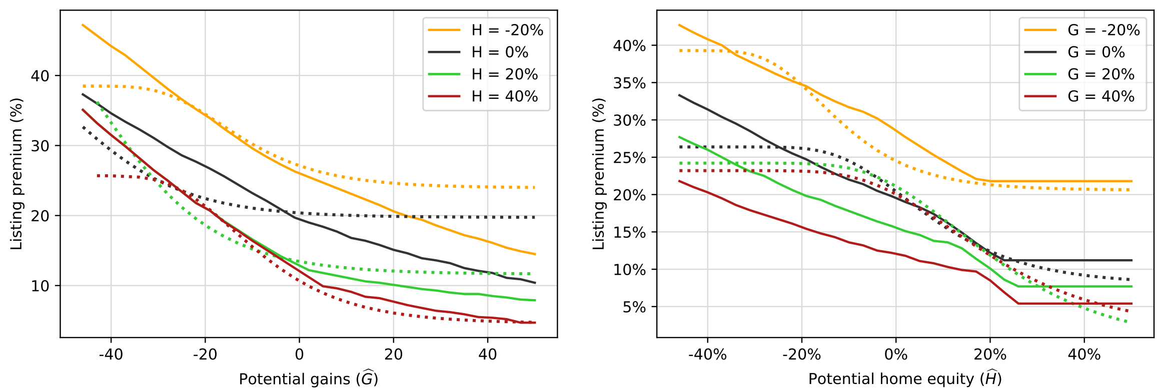


Table 1

Overview of moments and other estimates from the data

The table reports estimated empirical moments in the data. The first two capture the level and the slope of the listing premium with respect to the seller's level of potential gains, for $\widehat{G} > 0\%$, conditional on a home equity level of $\widehat{H} = 20\%$. The third moment is the slope of the listing premium with respect to potential home equity, for $\widehat{H} < 20\%$, conditional on gains of $\widehat{G} = 0\%$. The fourth and fifth moments are obtained as slope coefficients from cross-sectional regressions by municipality. For each municipality, we compute the slope $\ell - \widehat{G}$ for $\widehat{G} < 0\%$ and $\widehat{G} \geq 0\%$ respectively, as well as the concavity of demand (i.e. the slope $\alpha - \ell$ for $\ell > 0$). The sixth moment is the slope of the listing probability with respect to the potential gains, conditional on a home equity level of $\widehat{H} = 20\%$. The final moment captures the bunching of transactions around realized gains of 0%, calculated as the relative frequency of transactions in the [0,3%] interval of realized gains, relative to the [-3%,0) interval. In parentheses, we report bootstrap standard errors, clustered at the shire level. *, **, *** indicate statistical significance at the 10%, 5% and 1% confidence levels, respectively.

1.	Level of ℓ for $\widehat{G} = 0\%$	0.106***	(0.005)
2.	Slope ℓ–$\widehat{G}$ for $\widehat{G} < 0\%$	-0.490***	(0.047)
3.	Slope ℓ–$\widehat{H}$ for $\widehat{H} < 20\%$	-0.333***	(0.030)
4.	Cross-sectional slope ℓ–$\widehat{G}$–α for $\widehat{G} < 0\%$	-0.407***	(0.065)
5.	Cross-sectional slope ℓ–$\widehat{G}$–α for $\widehat{G} \geq 0\%$	-0.122**	(0.043)
6.	Slope of list. prob. by $\widehat{G}$	0.005**	(0.002)
7.	Bunching above $G = 0\%$	0.302***	(0.050)

Table 2
Estimated parameters

The table reports structural parameter estimates obtained through classical minimum distance estimation. We recover concave demand $\alpha(\ell)$ and $P(\ell)$ from the data and set the down-payment constraint $\gamma = 20\%$. In parentheses, we report standard errors based on the estimated bootstrap variance-covariance matrix in the data, clustered at the shire level. *, **, *** indicate statistical significance at the 10%, 5% and 1% confidence levels, respectively.

η	=	0.948^{***}	(0.344)
λ	=	1.576^{***}	(0.570)
μ	=	1.060^{***}	(0.107)
δ	=	-0.097^{***}	(0.009)
$\theta_{\min}$	=	0.217	(0.165)
$\theta_{\max}$	=	1.005^{***}	(0.197)
φ	=	0.037	(0.011)

Table 3

Listing premium-slope over gains and demand concavity slope regressions

This table reports regression results for the relationship between the listing premium slope over gains and demand concavity. The dependent variable in all regressions is the slope of the listing premium over $\widehat{G} < 0$ across municipalities.[58] Column 1 reports the baseline correlation with the demand concavity slope across municipalities using OLS. Column 2 reports the 2-stage least squares regression instrumenting demand concavity with the apartment- and row-house share. Columns 3 and 4 report the overidentified 2SLS regression with both instruments, row-house and apartment share and average distance to city, without and with household controls (age, education length, net financial assets and log income), respectively. In parentheses, we report bootstrap standard errors, clustered at the shire level. *, **, *** indicate statistical significance at the 10%, 5% and 1% confidence levels, respectively.

	OLS	2SLS		
	(1)	(2)	(3)	(4)
		Single IV	*Overidentified*	
Demand concavity	-0.407***	-0.520***	-0.504***	-0.346
	(0.067)	(0.111)	(0.087)	(0.259)
Household controls				✓
Observations	95	95	95	95
R^2	0.432			
First-stage F-stat		35.96	16.94	25.376
Hansen J-stat (p-val)			0.175	0.199

Reference Dependence in the Housing Market

Appendix

(For online publication)

Steffen Andersen* Cristian Badarinza† Lu Liu‡
Julie Marx§ Tarun Ramadorai¶

*Copenhagen Business School and CEPR, Email: san.fi@cbs.dk.
†National University of Singapore, Email: cristian.badarinza@nus.edu.sg
‡Imperial College London, Email: l.liu16@imperial.ac.uk.
§Copenhagen Business School, Email: jma.fi@cbs.dk.
¶Corresponding author: Imperial College London, Tanaka Building, South Kensington Campus, London SW7 2AZ, and CEPR. Tel.: +44 207 594 99 10. Email: t.ramadorai@imperial.ac.uk.

1 Further Details on Framework

1.1 Reference Dependence and Loss Aversion

Figure A.1 illustrates the seller's utility function for three cases. The first ($\eta = 0$) corresponds to the utility from terminal value of wealth. The second ($\eta > 0, \lambda = 1$) captures linear reference dependence and the third ($\eta > 0$ and $\lambda > 1$) reference-dependent loss aversion.

1.2 Derivation of $\widehat{G}_0$ and $\widehat{G}_1$

We now derive the potential gain levels $\widehat{G}_0$ and $\widehat{G}_1$ discussed in Figure 1 in the paper, for a simple case where the demand functions are linear: $\alpha(\ell) = \alpha_0 - \alpha_1 \ell$ and $\beta(\ell) = \beta_0 + \beta_1 \ell$.

In this case, expected utility is given by:

$$U^*(\widehat{G}) = \max_{\ell}(\alpha_0 - \alpha_1 \ell)\left[\underbrace{\widehat{P} + \beta_0 + \beta_1 \ell}_{P(\ell)} + \eta \underbrace{(\widehat{G} + \beta_0 + \beta_1 \ell)}_{G(\ell)} + \theta\right] + (1 - \alpha_0 + \alpha_1 \ell)\widehat{P}. \quad (1)$$

The first-order condition for the choice of ℓ^* is then:

$$\alpha_0(1+\eta)\beta_1 - \alpha_1\left[\widehat{P} + (1+\eta)\beta_0 + \eta\widehat{G} + \theta - \widehat{P}\right] - 2(1+\eta)\alpha_1\beta_1\ell^* = 0, \quad (2)$$

which implies the optimal solution:

$$\begin{aligned} \ell^*(\widehat{G}) &= \frac{\alpha_0(1+\eta)\beta_1 - \alpha_1\left[(1+\eta)\beta_0 + \eta\widehat{G} + \theta\right]}{2(1+\eta)\alpha_1\beta_1} \\ &= \frac{1}{2}\left(\frac{\alpha_0}{\alpha_1} - \frac{\beta_0}{\beta_1} - \frac{1}{\beta_1}\frac{\theta}{1+\eta} - \frac{1}{\beta_1}\frac{\eta}{1+\eta}\widehat{G}\right). \end{aligned} \quad (3)$$

For a model with loss aversion, the optimal listing premium is given by:

$$\ell^*(\widehat{G}) = \begin{cases} \frac{1}{2}\left(\frac{\alpha_0}{\alpha_1} - \frac{\beta_0}{\beta_1} - \frac{1}{\beta_1}\frac{\theta}{1+\eta}\right) - \frac{1}{2\beta_1}\frac{\eta}{1+\eta}\widehat{G}, & \text{if } \widehat{G} \geq \widehat{G}_0 \\ -\frac{\beta_0}{\beta_1} - \frac{1}{\beta_1}\widehat{G}, & \text{if } \widehat{G} \in (\widehat{G}_1, \widehat{G}_0) \\ \frac{1}{2}\left(\frac{\alpha_0}{\alpha_1} - \frac{\beta_0}{\beta_1} - \frac{1}{\beta_1}\frac{\theta}{1+\lambda\eta}\right) - \frac{1}{2\beta_1}\frac{\lambda\eta}{1+\lambda\eta}\widehat{G}, & \text{if } \widehat{G} \leq \widehat{G}_1. \end{cases} \quad (4)$$

1.3 Mapping Between Potential and Realized Gains

Realized gains result from a markup over potential gains, depending on the chosen optimal listing premium:[1]

$$G(\widehat{G}) = \widehat{G} + \beta(\ell^*(\widehat{G})) \tag{5}$$

Defining $\gamma_0 = \beta_0 + \frac{\beta_1}{2}\left(\frac{\alpha_0}{\alpha_1} - \frac{\beta_0}{\beta_1} - \frac{1}{\beta_1}\frac{\theta}{1+\eta}\right)$ and $\gamma_1 = 1 - \frac{1}{2}\frac{\eta}{1+\eta}$, we can simplify the expressions for the relationship between realized gains and potential gains:

$$G(\widehat{G}) = \gamma_0 + \gamma_1 \widehat{G} \tag{6}$$

With loss aversion, realized gains are then given by a step function:

$$G(\widehat{G}) = \begin{cases} \gamma_0 + \gamma_1 \widehat{G} & \text{if } \widehat{G} > \widehat{G}_0, \\ 0 & \text{if } \widehat{G} \in [\widehat{G}_1, \widehat{G}_0], \\ \gamma_{\lambda,0} + \gamma_{\lambda,1}\widehat{G} & \text{if } \widehat{G} < \widehat{G}_1. \end{cases} \tag{7}$$

Here, we have:

$$\widehat{G}_0 = -\frac{\gamma_0}{\gamma_1} \text{ and } \widehat{G}_1 = -\frac{\gamma_{\lambda,0}}{\gamma_{\lambda,1}}, \tag{8}$$

with $\gamma_{\lambda,0}$ and $\gamma_{\lambda,1}$ defined analogously to γ_0 and γ_1 above.

1.4 Extensive Margin Decision

When evaluated at the optimal level of the listing premium ℓ^*, expected utility is given by:

$$U^*(\widehat{G}) = \widehat{P} + \left[\alpha_0 - \alpha_1 \ell^*(\widehat{G})\right]\left[\eta\widehat{G} + (1+\eta)\left(\beta_0 + \beta_1\ell^*(\widehat{G})\right) + \theta\right] \tag{9}$$

Ignoring search costs, a sufficient statistic to capture the extensive margin decision is a cut-off level of the moving shock $\widetilde{\theta}$ for which:

$$U^*(\widehat{G}) = \underbrace{\widehat{P}}_{\underline{u}}, \text{ i.e.:}$$

$$\widetilde{\theta}(\widehat{G}) = -\eta\widehat{G} - (1+\eta)\left(\beta_0 + \beta_1\ell^*(\widehat{G})\right) \tag{10}$$

[1] Note that $G = \widehat{G} + \beta(\ell^*(\widehat{G})) = \beta_0 + \beta_1\widetilde{\gamma}_0 + (1 - \beta_1\widetilde{\gamma}_1)\widehat{G}$ if we define $\ell^*(\widehat{G}) = \widetilde{\gamma}_0 - \widetilde{\gamma}_1\widehat{G}$, and $\ell\lambda^*(\widehat{G}) = \widetilde{\gamma}_{\lambda,0} - \widetilde{\gamma}_{\lambda,1}\widehat{G}$.

Assuming that the moving shock is distributed according to the following cumulative distribution function:

$$\theta \sim F(\theta_{\min}, \theta_{\max}),$$

the listing probability s is given by:

$$s(\widehat{G}) = 1 - F(\widetilde{\theta}(\widehat{G})).$$

Substituting out equation (4) in (10), we get:

$$\begin{aligned}\widetilde{\theta}(\widehat{G}) &= -(\eta + (1+\eta)\beta_1\tilde{\gamma}_1)\widehat{G} - (1+\eta)(\beta_0 + \beta_1\tilde{\gamma}_0) \\ &= -\frac{\eta}{2}\widehat{G} - (1+\eta)(\beta_0 + \beta_1\tilde{\gamma}_0)\end{aligned}$$

We then have:

$$\frac{ds(\widehat{G})}{d\widehat{G}} = \frac{d\left(1 - F(\widetilde{\theta}(\widehat{G}))\right)}{d\widehat{G}} > 0.$$

1.5 Irrelevance of R with Utility from Passive Gains

We assume that households do not receive utility from simply living in a house that has appreciated relative to their reference point R, i.e. they do not enjoy utility from passive "paper" gains until they are realized. If this condition does not hold, the model is degenerate in that R is irrelevant both for the choice of the listing premium (intensive margin) and the decision to list (extensive margin). Consider the following utility function:

$$\begin{aligned}U =&\alpha(\ell)\left(P(\ell) + \underbrace{P(\ell) - R}_{G(\ell)}\right) + (1-\alpha(\ell))\left(\widehat{P} + \underbrace{\widehat{P} - R}_{\widehat{G}}\right) \\ =&2\alpha(\ell)P(\ell) + 2(1-\alpha(\ell))\widehat{P} - R.\end{aligned}$$

In this case, R is a simple scaling factor. It does not affect either marginal utility or marginal cost.

1.6 Specific Example of Extensive Margin Effects on Intensive Margin

To develop intuition, consider sellers with very high θ, who would naturally choose very low average listing premia. However, because of concave demand, such sellers will converge on the *the same* level ($\underline{\ell}$) of listing premia, the point beyond which there is no further improvement in the probability of sale. Put differently, if θ is sufficiently high, the chosen listing premium is essentially affected only by its effects on the probability of sale, and ℓ^* will barely respond to preferences (potential gains) and constraints (potential home equity). At the opposite end, if θ is very low (i.e., there are only tiny incentives to move), the average listing premium will be so high that responding to potential gains and losses is either immaterial or too costly. Taken together, if the distribution of θ is such that there is substantial mass in either (or both) of these areas, the average observed listing premium in the market will show no evidence of reference dependence, and appear unaffected by down-payment constraints.[2] More realistically, a more smooth distribution of θ will blur the effects of both reference dependence and constraints on the intensive margin.

1.7 Details on the Outside Option

To better understand the role of the outside option $\underline{u}$ in the model, we first look at the case in which it is independent of the reference point R. In this case, the decision of the seller is uniquely determined by the wedge between $\underline{u}$ and the magnitude of the search cost φ (if the listing fails), and the moving shock θ (if the listing succeeds). The choice of $\underline{u}$ is therefore immaterial for seller decisions or outcomes, and only affects the estimated magnitude and the interpretation of the search cost and moving shock φ and θ, respectively.

Choosing the normalization $\underline{u} = \widehat{P}$ seems most reasonable, because it implies that absent any additional reasons to move ($\theta = 0$) and with a zero cost of listing ($\varphi = 0$), the seller will be indifferent between staying in their home and getting the hedonic value in cash.

Alternatively, it may of course be that the reference level R is linked to the outside option. For example, a simple assumption is that $\eta = 0$ (i.e., sellers derive utility exclusively from the value of terminal wealth) while the outside option is $\underline{u} = R$, e.g. because the purchase price R is the seller's current estimate of house value. In this case, the optimal listing premium is a generic function: $\ell^* = f(\widehat{P} - R) = f(\widehat{G})$, which is identical to a model with $u = G$. However, there is little support for this specification in the data: In this case (i) the magnitude of reference dependence and the degree of loss aversion do not affect the slope of the listing premium with respect to $\widehat{G}$; this slope is uniquely pinned down by the demand "markup" functions, according to a set of implausible restrictions, (ii) loss aversion leads to a discrete jump at $G = 0$ and cannot generate the "hockey stick" pattern observed in the data, (iii) this model cannot explain the patterns of bunching at R that we observe.

Another possibility is that R enters the seller's estimation of value in a more refined form, indexed by a weighting factor κ, in addition to a (potentially mis-specified) hedonic value $\overline{P}$ estimated by the econometrician: $\widehat{P} = (1 - \kappa)\overline{P} + \kappa R$. To understand this case,

[2] Naturally, these patterns will also strongly be reflected in decisions along the extensive margin. This is a possibility that which we plan to explore in the future (e.g., most intuitively, the majority of low-θ owners may decide not to list), in a setup in which the drivers of the moving decision can be more clearly identified and mapped onto observable household characteristics.

note that the property's estimated value $\widehat{P}$ enters the model in two ways: First, it affects the final price $P(\ell) = \widehat{P} + \beta(\ell)$ realized in the market. Second, it affects the seller's outside option.

If the reference point R enters $\widehat{P}$ in the same way that it enters the outside option, R will drop out in the value comparisons that the seller makes and we infer (see Section 1.5). We can of course strongly reject this case, because of the strong impact of the reference point R on the intensive margin (i.e. the observed "hockey stick" in the data), the excess bunching of realized sales prices exactly at R, and the extensive margin effects, which demonstrate an influence of R on the probability of listing.

However, if R enters the seller's property value estimate (denoted by $\widehat{P}^{Seller}$ below) differently from how it enters $\widehat{P}$ we can distinguish between three cases: First, the seller correctly uses R when valuing the property, but we don't. This is possible, but we believe unlikely, given that our results hold strongly and robustly across a large number of alternative models for $\widehat{P}$, including repeat sales. But even if our hedonic model may miss relevant price variation coming from R, this only affects estimated effects in terms of potential gains $\widehat{G}$, and such a model cannot be reconciled with the evidence of excess bunching in *realized* gains G exactly around observed prices $P = R$. Second, sellers misperceive the importance of R, i.e. they weight it differently: $\widehat{P}^{seller} = (1 - \kappa)\widehat{P} + \kappa R$. The optimal listing premium function is then given by $\ell^* = f((\eta + \kappa)(\widehat{P} - R)) = f((\eta + \kappa)\widehat{G})$. In this case, reference dependence and irrational over-weighting of R have observationally equivalent effects on the *average slope* of the listing premium with respect to potential gains, but such a model of misspecified seller beliefs cannot explain the *variation* in slopes ("kinks"), and the bunching of realized prices around the reference point. Third, if both the econometrician and the seller incorrectly use R (and in different ways), we still extract the behaviour of interest, albeit potentially with considerable noise. More importantly, such a version of the model is also unable to explain the observed bunching of prices around the reference point.

2 Detailed Data Description

Our data span all transactions and electronic listings (which comprise the overwhelming majority of listings) of owner-occupied real estate in Denmark between 2009 and 2016. In addition to listing information, we also acquire information on property sales dates and sales prices, the previous purchase price of the sold or listed property, hedonic characteristics of the property, and a range of demographic characteristics of the households engaging in these listings and transactions, including variables that accurately capture households' financial position at each point in time. We link administrative data from various sources; all data other than the listings data are made available to us by Statistics Denmark. We describe the different data sources and dataset construction below.

2.1 Property Transactions and Other Property Data

We acquire administrative data on property transactions, property ownership, and housing characteristics from the registers of the Danish Tax and Customs Administration (SKAT). These data are available from 1992 to 2016. SKAT receives information on property transactions from the Danish Gazette (Statstidende)—legally, registration of any transfer of ownership must be publicly announced in the Danish Gazette, ensuring that these data are comprehensive. Each registered property transaction reports the sale price, the date at which it occurred, and a property identification number.

The Danish housing register (Bygnings-og Boligregister, BBR) contains detailed characteristics on the entire *stock* of Danish houses, such as size, location, and other hedonic characteristics. We link property transactions to these hedonic characteristics using the property identification number. We use these characteristics in a hedonic model to predict property prices, and when doing so, we also include on the right-hand-side the (predetermined at the point of inclusion in the model) biennial property-tax-assessment value of the property that is provided by SKAT, which assesses property values every second year.[3] SKAT also captures the personal identification number (CPR) of the owner of every property in Denmark. This enables us to identify the property seller, since the seller is the owner at the beginning of the year in which the transaction occurred.

In our empirical work, we combine the data in the housing register with the listings data to assess the determinants of the extensive margin listing decision for all properties in Denmark over the sample period. That is, we can assess the fraction of the total housing stock that is listed, conditional on functions of the hedonic value such as potential gains relative to the original purchase price, or the owner's potential level of home equity.

Loss aversion and down-payment constraints were originally proposed as explanations for the puzzling *aggregate* correlation between house prices and measures of housing liquidity, such as the number of transactions, or the time that the average house spends on the market. In Figure A.2 we show the price-volume correlation in Denmark over a broader period containing our sample period. The plot looks very similar to the broad patterns observed in the US.

[3]As we describe later, this is the same practice followed by Genesove and Mayer (1997, 2001); it does not greatly affect the fit of the hedonic model, and barely affects our substantive inferences when we remove this variable.

2.2 Property Listings Data

Property listings are provided to us by RealView (http://realview.dk/en/), who attempt to comprehensively capture all electronic listings of owner-occupied housing in Denmark. RealView data cover the universe of listings in the portal www.boligsiden.dk, in addition to additional data collected directly from brokers. The data include private (i.e., open to only a selected set of prospective buyers) electronic listings, but do not include off-market property transactions, i.e., direct private transfers between households. Of the total number of cleaned/filtered sale transactions in the official property registers (described below), 76.56 percent have associated listing data.[4] For each property listing, we know the address, listing date, listing price, size and time of any adjustments to the listing price, changes in the broker associated with the property, and the sale or retraction date for the property. The address of the property is de-identified by Statistics Denmark, and used to link these listings data to administrative property transactions data.

2.3 Mortgage Data

To establish the level of the owner's home equity in each property at each date, we need details of the mortgage attached to each property. We obtain mortgage data from the Danish central bank (Danmarks Nationalbank), which collects these data from mortgage banks through Finance Denmark, the business association for banks, mortgage institutions, asset management, securities trading, and investment funds in Denmark. The data are available annually for each owner from 2009 to 2016, cover all mortgage banks and all mortgages in Denmark and contain information on the mortgage principal, outstanding mortgage balance each year, the loan-to-value ratio, and the mortgage interest rate. The data contain the personal identification number of the borrower as well as the property number of the attached property, allowing us to merge data sets across all sources. If several mortgages are outstanding for the same property, we simply sum them, and calculate a weighted average interest rate and loan-to-value ratio for the property and mortgage in question.

[4] We more closely investigate the roughly 25% of transactions that do not have an associated electronic listing. 10% of the transactions can be explained by the different (more imprecise) recording of addresses in the listing data relative to the registered transactions data. The remaining 15% of unmatched transactions can be explained by: (a) off-market transactions (i.e., direct private transfers between friends and family, or between unconnected households); and (b) broker errors in reporting non-publicly announced listings ("skuffesager") to boligsiden.dk. We find that on average, unmatched transactions are more expensive than matched transactions. Sellers of more expensive houses tend to prefer the skuffesalg option for both privacy and security reasons.

2.4 Owner/Seller Demographics

We source demographic data on individuals and households from the official Danish Civil Registration System (CPR Registeret). In addition to each individual's personal identification number (CPR), gender, age, and marital history, the records also contain a family identification number that links members of the same household. This means that we can aggregate individual data on wealth and income to the household level.[5] We also calculate a measure of households' education using the average length of years spent in education across all adults in the household. These data come from the education records of the Danish Ministry of Education.

Individual income and wealth data also come from the official records at SKAT, which hold detailed information by CPR numbers for the entire Danish population. SKAT receives this information directly from the relevant third-party sources, e.g., employers who supply statements of wages paid to their employees, as well as financial institutions who supply information on their customers' balance sheets. Since these data are used to facilitate taxation at source, they are of high quality.

2.5 Final Merged Data

Our analysis depends on measuring both nominal losses and home equity. This imposes some restrictions on the sample. We have transactions data available from 1992 to the present, meaning that we can only measure the purchase price of properties that were bought during or after 1992. Moreover, the mortgage data run from 2009 to 2016. In addition, the sample is restricted to properties for which we know both the ID of the owner, as well as that of the owner's household, in order to match with demographic information.

For listings that end in a final sale, we drop within-household transactions and transactions that Statistics Denmark flag as anomalous or unusual. We flag (but do not drop) listings by households that do not have a stable structure, that is, we create a dummy for those listings for which the household ceases to exist as a unit in the year following the listing owing to death or divorce. We also flag households with missing education information. We restrict our analysis to residential households, in our main analysis dropping listings from households that own more than three properties in total, as they are more likely property investors than owner-occupiers.[6]

Once all filters are applied, the sample comprises 214,508 listings of Danish owner-occupied housing in the period between 2009 and 2016, for both sold (70.4%) and retracted

[5] Households consist of one or two adults and any children below the age of 25 living at the same address.

[6] Genesove and Mayer (2001) separately estimate loss aversion for these groups of homeowners and speculators. We simply drop the speculators in this analysis, choosing to focus our parameter estimation in this paper on the homeowners.

(29.6%) properties, matched to mortgages and other household financial and demographic information.[7] These listings correspond to a total of 191,843 unique households, and 179,262 unique properties. Most households that we observe in the data sell one property during the sample period, but roughly 9% of households sell two properties over the sample period, and roughly 1.5% of households sell three or more properties. In addition, we use the entire housing stock, filtered in the same manner as the listing data, comprising 5,540,376 observations of 807,666 unique properties to understand sellers' extensive margin decision of whether or not to list the properties for sale.

Table A.1 describes the cleaning and sample selection process from the raw listings data to the final matched data.

3 Summary Statistics

3.1 Liquid Financial Wealth

Figure A.4 Panel A shows the distribution of liquid financial assets in the sample. The wealthiest households in the sample have above 2 million DKK, which is roughly US$ 300,000 in liquid financial assets (cash, stocks, and bonds). The median level of liquid financial assets is 71,000 DKK and the mean in the sample is 247,000 DKK. When we divide *gross* financial assets by mortgage size, we find that households, at the median, could relax their constraints by around 6.25 percent if they were to liquidate all financial asset holdings. However, the right-hand side of the top panel of the figure shows that this would be misleading. Looking at *net* financial assets, once short-term non-mortgage liabilities (mainly unsecured debt) are accounted for, substantially changes this picture. The median level of net financial assets in the sample is -106,000 DKK and the mean is -136,000 DKK, and the picture shows that households' available net financial assets actually effectively *tighten* constraints for around 60 percent of the households in our sample. When we divide *net* financial assets by mortgage size we find, for households with seemingly positive levels of financial assets, that the constraints are in fact tighter by 9.3% at the median. Put differently, if households were to liquidate all financial asset holdings and attempt to repay outstanding unsecured debt, at the median, they would fall short by 9.3%, rather than be able to use liquid financial wealth to augment their down payments. We therefore control for the amount of net financial assets in several of our specifications to ensure that we accurately measure the impact of these constraints on household decisions. This is a significant advance, given the measurement concerns that have affected prior work in this area.

[7] The data comprises 173,065 listings that have a mortgage, and 41,443 listings with no associated mortgage (i.e., owned entirely by the seller)—we later utilize these subsamples for various important checks.

3.2 Age and Education

Given the natural reduction in labor income generating opportunities as households approach retirement, we might also expect that mortgage credit availability reduces as households age. And both age and education have been shown in prior work to affect the incidence of departures from optimal household decision-making (e.g., Agarwal et al., 2009, Andersen, et al., 2018), meaning that we might expect preference-based heterogeneity across households along these dimensions. Figure A.4 Panel B shows the age and education distributions of households in the sample. As expected, home-owning households with mortgages are both older and more educated than the overall distribution of households.

3.3 Gains, Losses and Home Equity – Independent Variation

There are several challenges associated with estimating the independent and joint effects of down-payment constraints and gains on households' listing decisions. One important challenge is that home equity and expected gains/losses are likely to be highly correlated with one another, mainly because of their joint dependence on $\widehat{\ln P}$. Other factors that influence this correlation are the LTV ratio at origination, and households' decisions to remortgage to higher levels or to engage in subsequent "cash-out" refinancing after the initial issuance of the mortgage. A second challenge in cleanly estimating the effects of both constraints and gains on household behavior is that their effects could interact in complex ways. This means that sufficient independent variation is necessary to be able to estimate any interaction effects with reasonable precision.

We therefore document the extent to which there is independent variation in gains and home equity in the data. We first provide a simple classification of the household-years in the data into four groups, based on estimated $\widehat{\ln P}$, the purchase price of the home R, and the mortgage amount M. The groups are:

1. Unconstrained Winners (50.2%): $\widehat{H} \geq 20\%$ and $\widehat{G} \geq 0$.
2. Constrained Winners (26.7%): $\widehat{H} < 20\%$ and $\widehat{G} \geq 0$.[8]
3. Unconstrained Losers (6.0%): $\widehat{H} \geq 20\%$ and $\widehat{G} < 0$
4. Constrained Losers (17.2%): $\widehat{H} < 20\%$ and $\widehat{G} < 0$

[8] $M > R$ is frequently observed in the data (47.2% of observations). This is primarily because of households' subsequent actions to remortgage to higher levels than their mortgage at issuance. This generally arises from "cash-out" refinancing, but could also arise from disadvantageous subsequent refinancing by homeowners, or fluctuations in adjustable rate mortgage payments causing households to increase mortgage principal to reduce monthly payment volatility.

The density of the data in each of the four groups is shown in Figure A.6. We show a vertical line at zero gains, and a horizontal line at 20% home equity. Under the assumption that households wish to move into a house of at least the same size as they currently own, and do not possess additional resources that they can bring to bear to augment the down payment, 20% current home equity is the constraint point, rather than zero home equity.

The figure shows that, as expected, there is a high correlation between the extent of home equity constraints and the gains and losses experienced by households. However, in our sample, there is considerable density off the principal diagonal of the plot. While this is reassuring, it could well be the case that this variation is confined to one particular part of the sample period, i.e., driven by time-variation in Danish house prices.

To check this, Figure A.7 plots the shares of seller groups in the data across each of the years in our sample. The figure shows that aggregate price variation does shift the relative shares in each group across years, with price rises increasing the fraction of unconstrained winners relative to losing and constrained groups. However, the relative shares still look fairly stable over the sample period, alleviating concerns that different groups simply come from different time periods, i.e., identification of any effects is likely to arise mainly from the cross section rather than the time series.

In addition, we note that the notion of constraints applies only if households are reluctant to downsizing. In Figures A.30 and A.31, we show, using a subsample of 14,939 households for which we can find two subsequent housing transactions and mortgage down-payment data, that there is a high correlation between the current house value, and the price of the next home that these households purchase, and that the price of the next home almost always lies above the price of the current house.

3.4 Generalized Logistic Functions and Interaction Effects

This rich set of interactions calls for a flexible and parsimonious model capable of capturing the observed shapes of the ℓ-$\widehat{G}$ and ℓ-$\widehat{H}$ relationships. To better document the facts about these patterns in the data, we estimate a simple model of reference points, borrowing a function commonly used in the biology literature to model the growth of organisms and populations. This is the generalized logistic function, also known as a Richards curve (Richards, 1959, Zwietering et al., 1990, Mead, 2017):

$$E[\ell(V)] = A + \frac{K - A}{(1 + Qe^{-BV})^{1/\nu}}. \tag{11}$$

Here, the parameters A and K control the lower and upper asymptotes of the sigmoid function, and the parameters Q, B and ν control the position of the reference (i.e. inflection) point as well as the slope of the sigmoid curve at the reference point.

Figure A.11 plots the relationships estimated using the model in equation (11). We set V first as gains ($V = \widehat{G}$), and next, as the level of home equity $V = \widehat{H}$. Panel A of the figure has $\widehat{G}$ along the x-axis, and ℓ along the y-axis. However, we now condition on three levels of $\widehat{H}$: the blue line shows the ℓ-$\widehat{G}$ relationship for households with levels of $\widehat{H}$ between 20 and 40% (i.e., effectively unconstrained households), while the red lines show the same relationship when households are increasingly constrained (the dashed red line when $\widehat{H}$ is between -5% and 20%, and the solid line when $\widehat{H}$ is between -15% and -5%).

To better understand these plots, we note that the average level of ℓ declines substantially as households become less constrained, and increases substantially as households become more constrained—this is simply the unconditional relationship between ℓ and $\widehat{H}$, seen in a different way in this plot. (Panel B of the figure shows the level differences that reflect the ℓ-$\widehat{G}$ relationship, i.e., higher levels of ℓ for those with high realized losses (in red) relative to those experiencing gains (blue)).

What is more interesting here is that controlling for this change in level, the *slope* of ℓ as a function of $\widehat{G}$ is also affected by the level of $\widehat{H}$. The important new fact is that down-payment-unconstrained households exhibit seemingly greater levels of reference dependence along the gain/loss dimension, exhibiting a pronounced increase in the slope to the left of $\widehat{G} = 0$. In contrast, down-payment constrained households exhibit a flatter ℓ across the $\widehat{G}$ dimension.

The bottom panel shows another interesting fact—along the home equity dimension, while the slope around the threshold does not change, *the position of the kink* in the listing premium *increases* with the level of past experienced gains.

3.5 Conditional Effects on Listing Premia

Of course, these observations could simply be capturing the effect of other potential determinants for which the plots do not control, and indeed, we may be concerned yet again about the independent effects of $\widehat{G}$ and $\widehat{H}$ on ℓ. To check whether these conditional effects do indeed exist controlling for one another, and for a range of other determinants, and to verify whether they are statistically significant, we estimate the following piecewise-linear specification:

$$\begin{aligned}\ell_{it} = \mu_t + \mu_m + \boldsymbol{\xi_0}\mathbf{X_{it}} + \boldsymbol{\xi_1}\mathbf{B_{it}} + \alpha_1 \mathbb{1}_{G_{it}<0} + \alpha_2 \mathbb{1}_{\mathrm{H}_{it}<20\%} \\ + (\beta_0 + \underbrace{\beta_1 \mathbb{1}_{G_{it}<0}}_{\text{Gains}} + \boldsymbol{\beta_2}\mathbf{B_{it}} + \underbrace{\boldsymbol{\beta_3}\mathbb{1}_{G_{it}<0}\mathbf{B_{it}}}_{\text{Conditional effect}})G_{it} \\ + (\gamma_0 + \underbrace{\gamma_1 \mathbb{1}_{\mathrm{H}_{it}<20\%}}_{\substack{\text{Down-payment}\\ \text{constraint}}} + \boldsymbol{\gamma_2}\mathbf{B_{it}} + \underbrace{\boldsymbol{\gamma_3}\mathbb{1}_{\mathrm{H}_{it}<20\%}\mathbf{B_{it}}}_{\text{Conditional effect}})\mathrm{H}_{it} \\ + \varepsilon_{it}. \end{aligned} \quad (12)$$

Equation (12) allows ℓ to depend (piecewise) linearly on both home equity $\widehat{H}$ and gains $\widehat{G}$ (through β_0, γ_0). We include time (μ_t) and municipality (μ_m) fixed effects, and controls $\mathbf{X_{it}}$ (household age, years of education, and net financial assets). The piecewise linear specification also allows for kinks in the linear relationship at a reference point of 0 for nominal gains, and 20% for home equity through β_1 and γ_1—these coefficients capture the "unconditional" effects of gains and home equity on household behavior. The baseline estimation is reported in Table A.7. To capture the conditional behavior, we bin both home equity and gains (as well as the other conditioning variables) and introduce dummy variables $\mathbf{B}$ into the regression of the respective other dimension to capture the different ℓ-$\widehat{G}$ (and ℓ-$\widehat{H}$) relationships for these groups. We allow for $\mathbf{B}$ to modify both the unconditional relationship with $\widehat{G}$ and $\widehat{H}$ (β_2, γ_2), as well as any slope differential at the reference points (β_3, γ_3).[9]

Despite the considerable number of parameters in equation (12), the estimates point to interesting conditional variation in the data. The y-axis of Panel A of Figure A.8 shows the point estimate for the slope of the ℓ-$\widehat{G}$ relationship for different bins of household covariates shown on the x-axis.

Panel B of Figure A.9 investigates the effect of down-payment constraints, conditioning the ℓ-$\widehat{H}$ relationship on the level of household covariates.

4 Measuring Concave Demand

Figure A.3 shows the distribution of time-on-the-market (TOM) in the data. We winsorize this distribution at 200 weeks, viewing properties that spend roughly 4 years on the market as essentially retracted. Mean (median) TOM in the data is 37 weeks (25 weeks). This is higher than the value of roughly 7 weeks reported in Genesove and Han (2012).

We next inspect the inputs to the function $\alpha(\ell)$ in the data. The top plot in Figure

[9]Since we do not want to model any higher-order effects in this context, we exclude the respective gains bins from $\mathbf{B}$ when interacted linearly with the gains variable, and home equity bins when interacted linearly with the home equity variable. That is, we allow only for "cross-effects" in this specification.

A.10 shows how TOM relates to the listing premium ℓ in the data using a simple binned scatter plot. When ℓ is below 0, TOM barely varies with ℓ; however, TOM moves roughly linearly with ℓ when ℓ is positive and moderately high. Interestingly, we also observe that the relationship between ℓ and TOM flattens out as ℓ rises to very high values above 40%. This behavior is mirrored in the bottom panel of Figure A.10, which shows the share of seller *retracted* listings, which also rises with ℓ. Here we also see more "concavity" as $\hat{\ell}$ drops below zero, in that the retraction rate rises the farther $\hat{\ell}$ falls below zero.

In the paper, we simply convert the two plots into a single number, which is the probability of house sale within six months (i.e., $\alpha(\hat{\ell})$) on the y-axis as a function of $\hat{\ell}$ on the x-axis. To smooth the average point estimate at each level of the listing premium, we use a generalized logistic function (Richards, 1959, Zwietering et al., 1990, Mead, 2017) of the form:

$$\alpha(\ell) = A + \frac{K - A}{(C + Qe^{-B\ell})^{1/\nu}}, \tag{13}$$

5 Robustness Against Unobserved Heterogeneity

We find an asymmetric relationship between the listing premium ℓ and potential gains $\widehat{G}$ over the loss domain, as well as an asymmetric decrease in the probability of sale when listing premia are greater than zero, as captured in the function $\alpha(\ell)$ ("demand concavity"). In the following, we show that the observed non-linearities are robust to a range of underlying models for $\widehat{P}$, and using additional methods to deal with potentially unobserved heterogeneity from different sources.

5.1 Unobserved Quality and the Listing Premium over Potential Gains

We follow Genesove and Mayer (2001) to illustrate potential confounds. For simplicity, the "hockey stick" relationship between listing premia and potential gains can be expressed in a regression framework as measuring the slope of the effect of gains less than 0 on the listing premium. The regression equation is then:

$$\ell_{ijst} = \alpha + \beta\mathbb{I}[G < 0] \underbrace{(\ln P_{it} - \ln R_{ijs})}_{\text{"True" gain } G} + \epsilon_{ijst}, \tag{14}$$

for a property i sold by household j at time t, with initial purchase taking place at time s, yielding reference price R_{ijs}, and where $\ln P_{it} = \widehat{\ln P_{it}} + v_i$, i.e. the "true" market value of the house known to the seller is the estimated hedonic value plus an unobserved property-i specific component. In addition, we assume that the log reference price $\ln R_{ijs}$ can also be decomposed into three components $\ln \widehat{P_{is}} + \nu_i + \omega_{ijs}$, that is the estimated market value, the unobserved quality of the property, and the degree to which buyers under-or overpaid for the property at time s, ω_{ijs}. Instead of the "true" listing premium ℓ that the seller chooses, we measure $\widehat{\ell_{ijst}} = \ln L_{ijst} - \ln \widehat{P_{it}}$. The log listing price $\ln L_{ijst}$ also comprises three components: the estimated market value $\widehat{P_{it}}$, the unobserved quality of the house ν_i, and the true listing premium ℓ_{ijst}. Substituting yields

$$\widehat{\ell_{ijst}} = \ln L_{ijst} - \ln \widehat{P_{it}} = \nu_i + \ell_{ijst}. \tag{15}$$

Equation 15 reflects the inference problem that a potential buyer faces: the buyer would be willing to pay more for quality ν_i, but not for the seller-specific premium ℓ_{ijst}.[10] The ideal regression can hence be written as

$$\ell_{ijst} = \alpha + \beta \mathbb{I}[\widehat{\ln P_{it}} + \nu_i - (\widehat{\ln P_{is}} + \omega_{ijs} + \nu_i) < 0](\widehat{\ln P_{it}} + \nu_i - (\widehat{\ln P_{is}} + \omega_{ijs} + \nu_i)) + \epsilon_{ijst} \tag{16}$$

$$= \alpha + \beta \mathbb{I}[\widehat{\ln P_{it}} - (\widehat{\ln P_{is}} + \omega_{ijs}) < 0](\widehat{\ln P_{it}} - (\widehat{\ln P_{is}} + \omega_{ijs})) + \epsilon_{ijst} \tag{17}$$

In contrast, the feasible regression is

$$\widehat{\ell_{ijst}} = \alpha + \beta \mathbb{I}[\widehat{\ln P_{it}} - (\widehat{\ln P_{is}} + \omega_{ijs} + \nu_i) < 0](\widehat{\ln P_{it}} - (\widehat{\ln P_{is}} + \omega_{ijs} + \nu_i)) + \eta_{ijst}, \tag{18}$$

such that

$$\eta_{ijst} = \epsilon_{ijst} + \nu_i + \beta(\mathbb{I}[\widehat{\ln P_{it}} - (\widehat{\ln P_{is}} + \omega_{ijs} + \nu_i) < 0](\widehat{\ln P_{it}} - (\widehat{\ln P_{is}} + \omega_{ijs} + \nu_i)) - \mathbb{I}[\widehat{\ln P_{it}} - (\widehat{\ln P_{is}} + \omega_{ijs}) < 0](\widehat{\ln P_{it}} - (\widehat{\ln P_{is}} + \omega_{ijs}))). \tag{19}$$

As noted by Genesove and Mayer, the two sources of bias that are caused by this substitution are: first, since ν_i and ω_{ijs} are unobservable, and both appear in the term measuring gains, it should generate classical measurement error, biasing β towards zero.[11] Second, the unobserved quality component ν_i induces a negative correlation with gains (intuitively, gains are overestimated if the true value of the property is higher), likely leading to negative bias in the estimate of β. Since β is expected to have a negative sign, this may cause the steepness of the slope to be overestimated.

We propose the following five robustness checks to validate that the asymmetry in the listing premium over potential gains is not driven by unobserved quality and other con-

[10] This is captured in our characterization of the demand side: if ν is relatively easy to discern (e.g. given a very homogeneous housing stock), any increase in ℓ gets penalized more strongly, i.e. the probability of a quick sale decreases more sharply.

[11] Note there is a nonlinearity here which is a departure from the classical measurement error framework, but Genesove and Mayer confirm that this source of bias leads to attenuation.

founds.

1) We use alternative pricing models of $\widehat{\ln P}$ and in particular a repeat sales model to absorb time-invariant unobserved property quality ν_i. The key intuition is that we have repeat sales of property i in the sample, such that we can estimate a pricing model ($\ln \widehat{P_{it}^{repeat}}$) with property fixed effects that differences out ν_i. The model estimation is further detailed below. This allows us to measure the true listing premium ℓ set by the seller as $\widehat{\ell_{ijst}^{repeat}} = \ln \widehat{P_{it}^{repeat}} + \ell_{ijst} - \ln \widehat{P_{it}^{repeat}} = \ell_{ijst}$. If we further assume that $\omega_{is} = \ln \widehat{P_{is}^{repeat}} - \widehat{\ln P_{is}}$ and that ω does not vary further across households, we can measure

$$\ell_{ijst} = \alpha + \beta \mathbb{I}[\ln \widehat{P_{it}^{repeat}} - (\ln \widehat{P_{is}^{repeat}} + \omega_{is}) < 0](\ln \widehat{P_{it}^{repeat}} - (\ln \widehat{P_{is}^{repeat}} + \omega_{is})) + u_{ijst}, \quad (20)$$

which comes close to the ideal equation. Figure A.14 shows that the listing premium slope for gains less than zero using repeat sales models for $\ln \widehat{P}$ is comparable to that of the baseline hedonic model without property fixed effects, assuaging concerns that the hockey stick shape is driven by unobserved quality.

2) Next, we substitute shire-level house prices for $\widehat{\ln P}$. This is the reduced form exercise to the IV strategy where we instrument $\ln P_{it}$ (and hence $\widehat{G}$) using $\ln P_t^{shire}$, which is correlated with the property-specific $\ln P_{it}$, but plausibly exogenous to ν_i and ω_{ijs}. The intuition behind this is that households may be able to endogenously affect $\ln P_{it}$ via e.g. unobserved maintenance efforts, but not $\ln P_t^{shire}$.

3) We control for further observables in addition to home equity. As we show, ℓ_{ijst} is set by seller j in line with ijt-specific confounds ξ_{ijt}, most prominently home equity, but also liquidity, demographics, municipality-and time specific-factors, which we observe in our granular data.

4) We replicate the bounding approach as suggested by Genesove and Mayer (2001). They show that controlling for the residual from the previous sales price as a noisy proxy for unobserved quality yields a lower bound for the coefficient on loss (in our case, gain), while not controlling yields an upper bound effect in line with the bias described above. Table A.8 which replicates Table 2 in their paper using our data shows that we get a coefficient of 0.44 to 0.53, meaning that a 10 percent increase in the loss faced is associated with a 4.4 to 5.4% higher list price, similar to and even slightly larger than their bounds of 2.5 to 3.5%.

5) Lastly, while 1) to 4) focus on the magnitude of the listing premium slope, we document evidence in line with the key predictions from the model, that the slope changes discontinuously around the threshold, using a regression kink design (RKD). In particular, we show that the slope to the left of zero increases significantly, and that other property-and household-specific observable characteristics are smooth around the threshold, in line with the identifying assumptions of the design. The RKD estimation is described further below.

5.2 Unobserved Quality and Demand Concavity

We find an asymmetric relationship between listing premia and the probability of sale within six months, which is relatively flat for listing premia smaller equal zero, and decreasing for listing premia greater than zero, i.e. demand is concave, in line with Guren (2018). Unobserved quality as described in equation 15 is again a potential confound to this relationship, as properties with greater observed listing premia purely driven by unobserved quality would be expected to sell faster, leading to an upward bias in the observed demand concavity.

In order to provide robustness for our results, we again 1) use a repeat sales model for $\widehat{P}$ to account for time-invariant unobserved quality. The results are shown in Figure A.14 Panel B, where the slope to the right of a zero listing premium is indeed steeper (more negative) using repeat sales models.
2) We also use shire-level house prices to instrument for individual property prices, which are plausibly exogenous to property-specific unobserved quality. We also control for detailed property-specific observables.
3) Lastly, we also perform a regression kink design analysis and find that there is a significant change in slope to the right of zero listing premia, while other property-specific observable characteristics appear smooth around the threshold.

5.3 Hedonic Pricing Model and Alternatives

The following describes the baseline hedonic pricing model and alternative models in more detail.

5.3.1 Baseline Hedonic Model

We estimate the expected market price using a hedonic price model on our final sample of traded properties and predict prices for the entire sample of listed properties. The price in logs is estimated using the hedonic model

$$\begin{aligned} ln(P_{it}) = \xi + \xi_t + \xi_m + \xi_{tm} + \beta_{ft}\mathbb{1}_{i=f}\mathbb{1}_{t=\tau} \\ + \boldsymbol{\beta}\mathbf{X_{it}} + \boldsymbol{\beta_{fx}}\mathbb{1}_{i=f}\mathbf{X_{it}} \\ + \Phi(v_{it}) + \mathbb{1}_{i=f}\Phi(v_{it}) + \varepsilon_{it}. \end{aligned}$$

ξ is a constant, ξ_t are year fixed effects, ξ_m are municipality fixed effects (98 municipalities in total), and ξ_{tm} are municipality-year fixed effects. $\mathbb{1}_{i=f}$ is an indicator variable for whether the property is an apartment (denoted by f for flat) rather than a house. $\mathbf{X_{it}}$ is a vector of the following property characteristics: ln(lot size), ln(interior size), number of rooms, number of bathrooms, number of showers, a dummy variable for whether the property was unoccupied at the time of sale or retraction, ln(age of the building), a dummy variable for whether the property is located in a rural area, a dummy for whether the building is registered as historic, ln(distance to nearest of Denmarks four largest cities). $\Phi(v_{it})$ is a third-order polynomial of the previous-year tax assessed valuation of the property. The R^2 of the regression is 0.8638. The model fit is shown in Figure A.5.

5.3.2 Repeat Sales Estimation

To control for time-invariant unobserved heterogeneity in properties, we apply property fixed effect in a repeat sales sample. Since the hedonic model is based on our final sample of sold listings from 2009-2016, we run the fixed effects model on repeat sales within our final sample, but due to the short window, repeat sales are not as frequent. In order to increase repeat sales sample size, we also estimate the fixed effect model on repeat sales in the entire population of Danish real estate sales from 1992 to 2016. We estimate $\widehat{ln(P_{it})}$ using the model:

$$\begin{aligned} ln(P_{it}) = {} & \xi + \xi_t + \xi_m + \xi_{tm} + \xi_p + \beta_{ft}\mathbb{1}_{i=f}\mathbb{1}_{t=\tau} \\ & + \boldsymbol{\beta}\mathbf{Y_{it}} + \boldsymbol{\beta}_{\mathbf{fy}}\mathbb{1}_{i=f}\mathbf{Y_{it}} \\ & + \Phi(v_{it}) + \mathbb{1}_{i=f}\Phi(v_{it}) + \varepsilon_{it}. \end{aligned}$$

with ξ_p being property fixed effects and $\mathbf{Y_{it}}$ being a vector of the following (potentially) time-invariant property characteristics: ln(interior size), number of rooms, number of bathrooms, number of showers, a dummy variable for whether the property was unoccupied at the time of sale or retraction, ln(age of the building), a dummy for whether the building is registered as historic. R^2 from estimation of the model is 0.9011.

5.3.3 Additional Models of $\widehat{P}$

We further include house prices estimated based on a municipality-, and shire-level house price index, respectively, and a model extension using size interactions and cohort (purchase year) fixed effects. An overview of the alternative model specifications is given in Table A.3 and the results are compared in Figures A.12 and A.13.

5.3.4 Out-of-sample Testing

The large number of controls and fixed effects in the hedonic model could give rise to concerns about overfitting. To test for overfitting, we conduct out-of-sample testing. Table A.4 reports mean R^s from 1000 iterations of sampling of 50, 75 and 100 percent, respectively, and Figure A.15 show distributions of the R^s from the 1000 iterations. The model performs well even for models estimated on small samples.[12]

Figure A.16, A.17, and A.18 show that the listing premium to gains and the listing premium to home equity relationships as well as the demand cancavity hold, also when the hedonic price is predicted out-of-sample.

5.3.5 Hedonic Model and the Tax-assessed Value

The accuracy of the hedonic model is improved by including the pre-determined tax-assessed value and in addition adjusting for the current local price development, using municipality-year fixed effects. But even without including the tax-assessed value, our hedonic model performs well. Table A.6 decomposes the hedonic model and shows the R^2 contribution from each component. In itself the tax-assessed value explains 78 percent of the variation of sales prices, and municipality-year fixed effects explain 47 percent. Our baseline hedonic model without tax-assessed value explains 76 percent of the variation in sales prices and adding the third degree polynomial of the tax-assessed value increases explanatory power to 87 percent.

The tax-assessed value in itself stems from a very comprehensive model, developed by the Danish tax authorities (SKAT). Relative to our data, the tax-assessment model utilizes more detailed data parameters such as distance to local facilities like schools and public transport. In addition, in some cases (prior to 2013) the assessment is manually adjusted by the tax authorities if the mechanically set value is opposed by owners or if the property is in the right tail of the distribution. Overall we include the tax-assessed value in our model because it adds information beyond what we observe.

However, the tax-assessed value is in itself inferior to our model, since it - especially in the period of our data - underestimates price levels, see Figure A.22 panel (a). Due to systematic misvaluations, in 2013 the tax assessments were frozen at 2011 levels in order to develop a new model of assessment. As of 2020 the new model is not yet in use. Figure A.22 panel (b) and (c) clearly illustrate the shortcomings of the tax assessment in our sample period in particular. The figures show how the tax assessment was backwards-looking and as a result lagged behind realized prices in the housing market boom prior to the financial crisis and in the bust during the crisis. Starting from 2013 the tax assessment decouples from market prices.

Figure A.19, A.20, and A.21 show that the relationships between gains and listing premium, beetween home equity and listing premium, and demand concavity hold when using the tax assessment in the years it is most accurate instead of the hedonic price, although

[12]It could potentially be because of the inclusion of the tax-assessed value in the model, since the tax-assessed value in itself is a the outcome of a full sample model. However, although excluding the tax-assessed value from the model reduces the R^2, small samples still provide good fits. See Table A.5.

the level of the listing premium is higher (due to the assessed value underestimating the market value, as discussed).

5.4 Genesove and Mayer (2001) Bounding Approach

We follow Genesove and Mayer (2001) to establish bounds on the relationship between expected gains and list prices given unobserved heterogeneity and variation in over-and under-payment at the previous transaction. The idea is to include the pricing residual relative to the previous sales price as a noisy proxy for unobserved quality to get a lower bound estimate for the coefficient on loss (in our case, gain), while not controlling for it yields an upper bound effect in line with the bias described above. In particular, we replicate Table 2 in their paper in Table A.8. As a baseline, comparing column (2) and (1), the effect from a 10% increase in expected losses can be bounded between a 4.4 to 5.4% increase in list prices, compared to their 2.5 lower bound and 3.5% upper bound estimate.

5.5 Regression Kink Design (RKD)

We implement a regression kink design (RKD) to establish a significant change in slope in a narrow neighbourhood around $\widehat{G} = 0$ (for $\hat{\ell}$) and in $\hat{\ell} = 0$ (for $\alpha(\hat{\ell})$), while other observable characteristics are visibly smooth around $\widehat{G} = 0$ and $\ell = 0$. The design (suggested by Card et al. 2015b and implemented e.g., by Landais, 2015, Nielsen et al. 2010, Card et al. 2015a) relies on quasi-random assignment at thresholds of particular "running variables" that induce kinks in agents' responses. As long as households can only imperfectly manipulate which side of the threshold they are on, the resulting differences in behavior above and below the threshold can be interpreted as causal. The identifying assumption relies on other confounds being smooth around the threshold, e.g. in our case, that unobserved property quality should not have a significant kink precisely at the threshold.

Following Card et al. (2017), we compute the RKD estimate of a given running variable V as follows:

$$\tau = \lim_{v \to \overline{v}_+} \frac{dE[\ell_{it}|V_{it} = v]}{dv}\bigg|_{V_{it}=v} - \lim_{v \to \overline{v}_-} \frac{dE[\ell_{it}|V_{it} = v]}{dv}\bigg|_{V_{it}=v}, \tag{21}$$

based on the following RKD specification (Landais 2015):

$$E[\ell_{it}|V_{it} = v] = \kappa_m + \kappa_t + \boldsymbol{\xi}\mathbf{X_{it}} + \left[\sum_{p=1}^{\overline{p}} \gamma_p(\nu - \overline{v})^p + \nu_p(v - \overline{v})^p \mathbb{1}_{V \geq \overline{v}}\right]. \tag{22}$$

$$\text{where } |v - \overline{v}| < b. \tag{23}$$

As before, we include time (κ_t) and municipality (κ_m) fixed effects, and controls $\mathbf{X_{it}}$. These include household characteristics (age, education length, and net financial assets), as well as the previous purchase year, which we include to ensure that households are balanced along the dimension of housing choice, and is predetermined at the point of inclusion in this specification. V is the assignment variable, $\overline{v}$ is the kink threshold, $\mathbb{1}_{V \geq \overline{v}}$ is an indicator whether the experienced property return is above the threshold, and b is the bandwidth size.

To estimate the change in listing premium slope across gains, we choose $V = \widehat{G}$ as the assignment variable, and $\overline{v} = 0$ as the kink point. To estimate the effect of demand concavity, $V = \ell$, with a baseline kink threshold of $\overline{v} = 0\%$. Table A.10 reports results across bandwidths $b \in \{b^*, 15, 20\}$ around each of the running variables. b^* denotes the mean-squared-error optimally chosen bandwidth following Calonico et al (2014) and we use a polynomial order $p = 2$ for gains, and $p = 1$ for demand concavity.[13] Figures A.24 to A.26 show further robustness for the RKD using gains.

6 Bunching Estimates Robustness

We conduct several robustness checks for bunching in realized gains around the reference point of the previous sales price. First, we show the prevalence of listings and sales at round numbers in Figure A.37. We then show the distribution of realized gains by excluding sales at rounded prices of 10,000 and 50,000 DKK (Figure A.38) and 100,000 and 500,000 DKK (Figure A.39), respectively. We further show that bunching is robust across all quintiles of the previous sales price (Figure A.40) and when splitting into quintiles by holding period, except for the sub-sample with holding periods of greater than 12 years (top quintile), where there is limited mass of households who are around the zero realized gain threshold.

7 Institutional Background

7.1 Amendments to the Danish Mortgage-Credit Loans and Mortgage-Credit Bonds Act

Changes to the law regulating the loan-to-value ratio of mortgage loans between 2009 to 2016 are listed in Table A.16.

[13]The precision but not the size of the estimate for unconstrained households depends on the use of a local linear compared to a local quadratic function. Hahn et al. (2001) show that the degree of the polynomial is critical in determining the statistical significance of the estimated effects. In particular, the second-order polynomial needed to identify derivative effects leads to an asymptotic variance of the estimate that is larger by a factor of 10 relative to the first-order polynomial. We verify that the qualitative patterns that we detect are broadly unaffected by the use of either polynomial order, but that the standard errors, consistent with Hahn et al. (2001), are substantially higher for the second-order polynomial, reported in Figure A.27.

7.2 Foreclosures

Homeowners who cannot pay their mortgage or property tax may benefit from selling their home -– even if they have negative home equity — since they otherwise risk to be declared personally bankrupt by their creditors. If declared personally bankrupt, the property will be sold at a foreclosure auction. Foreclosures in most cases result in prices significantly below market price. Selling in the market will thus potentially allow homeowners to repay a bigger fraction of their debt. Homeowners with negative home equity may even be tempted to set higher listing prices to cover an even higher fraction of the debt. Whether this is optimal is debatable, since setting a higher listing price probably also reduces the probability of selling the property before a foreclosure process could begin.

7.3 The Foreclosure Process in Denmark

A foreclosure takes place if a homeowner repeatedly fails to make mortgage or property tax payments. After the first failed payment, the creditor (the mortgage lender or the tax authorities) first send reminders to the home owners and after approximately six weeks send the case to a debt collection agency. If the home owner after two to three months still fails to pay the creditor, the creditor will go to court (Fogedretten) and initiate a foreclosure. The court calls for a meeting between the owner and the creditor to guide the owner in the foreclosure process. At the meeting the owner and creditor can negotiate a short extension of four weeks to give the owner a chance to sell the property in the market. If that fails, the court has another four weeks, using a real estate agent, to attempt to sell the property in the market. After the attempts to sell in the market, the creditor will produce a sales presentation for the foreclosures, presenting the property and the extra fees that a buyer has to pay in addition to the bid price. The court sets the foreclosure date and at least two weeks before announces the foreclosure in the Danish Gazette (Statstidende), online, and in relevant newspapers. At the foreclosure auction interested buyers make price bids and highest bid determines the buyer and the price. If the buyer meets some financial requirements, the buyer takes over the property immediately and the owner is forced out. However, the owner can (and often will) ask for a second auction to be set within four weeks from the first. All bids from the first auction are binding in the second, but if a higher bid appears, the new bidder will win the auction.

The entire process from first failed payment to foreclosure typically takes six to nine months. At any point the owner can stop the foreclosure process by selling in the market and repaying the debt.

Selling in the market is preferred to foreclosure since foreclosure prices are significantly lower than market prices. Buyers have few opportunities to assess the house and have to buy the house "as seen" without the opportunity to make any future claims on the seller, making it a risky trade. In addition, buyers have to pay additional fees of more than 0.5 percent of the price.

7.4 Assumability and Refinancing

Mortgages in Denmark are generally assumable, i.e. sellers can transfer their mortgage to the buyer at sale (Berg et al. 2018). Borrowers also have the option to repurchase their fixed-rate-mortgage from the covered bond pool at market or face value. Both market features alleviate potential seller lock-in, in particular in a rising rate environment (Campbell 2012). In our sample period, over 2009-2016, rates are broadly decreasing, which generates incentives to refinance. Another question is if the assumability of mortgages can relax down-payment constraints, and hence generate additional gains by purchasing a house with a specific mortgage value. In general, any mortgage assumption needs the approval from lenders, who enforce the 20% down-payment constraint for the assumed debt. For instance, if a household sells a house with value $P = 90$ and mortgage balance $M = 80$ to buy a house with value $P = 90$ and mortgage balance $M = 80$, the household can only assume $M = 0.8 \times 90 = 0.72$ and hence requires an additional down payment. It is very rare (but possible) to assume a mortgage with an LTV > 80 after negotiation with the lender, but the mortgage interest rate tends to be expensive (e.g. currently, a 140 bp total fee above the coupon rate). Another benefit of assuming the mortgage is to save the 150bp stamp duty due on new mortgage debt, with a maximum 120 bp benefit at 80% LTV, which households would need to trade-off against the increase in search cost to find a house with high assumable debt, given time, location, and preference constraints.

7.5 Property Taxation in Denmark

SKAT assess the property value to determine the amount of tax to be paid on real estate. The exact rate of property taxation varies across municipalities, but the assessed value is set centrally. In Denmark there is no tax on realized capital gains if the owner "has lived" in the house/apartment, under the condition that the house must not be extremely large (lot size smaller than 1400 sqm). It is not necessary for the owner to live in the property at the time of the sale, but she needs to establish that the property was not used under a different capacity (such as renting to a public authority) before the sale. The "substantial occupation requirement" used to be two years, but now requires only documentation of utilities use, registration etc. Capital gains that do not fall under this exception are taxed like other personal income. Taxation on gifts to family members stands at 15% above 65,700 DKK (as of 2019). However, home owners can also give the property to a child with an interest-free, instalment-free debt note terminated at the time of sale. Heirs can inherit houses and any associated tax exemptions on sale in the event of death of the principal resident.

8 Additional Tables and Figures

Figure A.1
Reference Dependence and Loss Aversion: Utility Functions

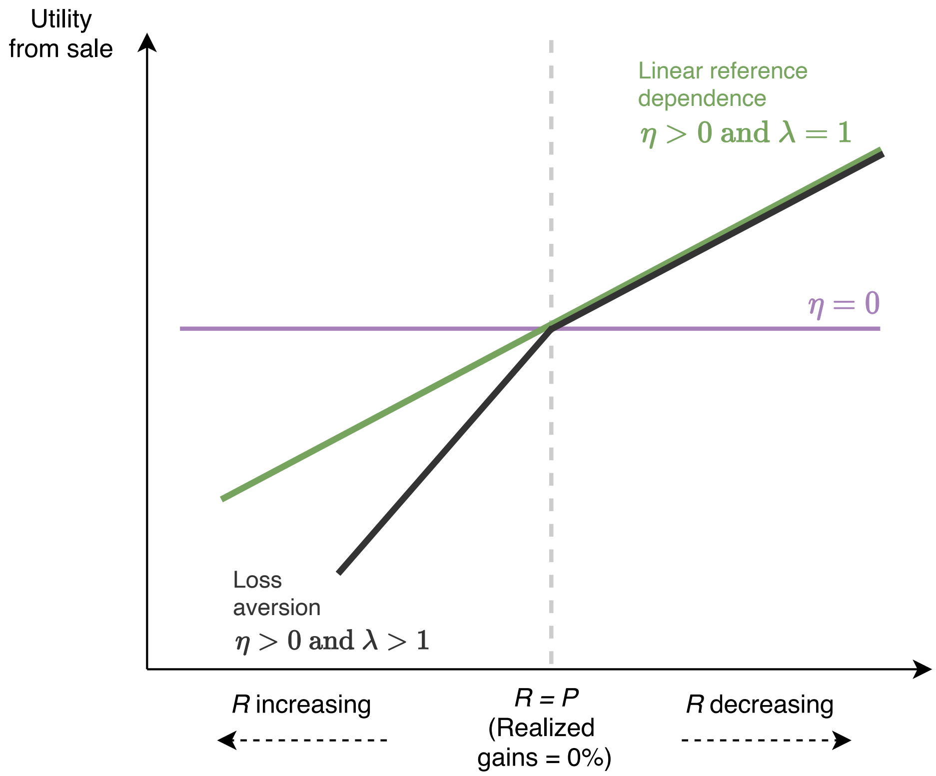


Figure A.2
Price-Volume Correlation

This figure shows quarterly average realized house sales prices (in DKK per square meter) on the right-hand axis, and the number of houses sold in Denmark on the left-hand axis, between 2004Q1 and 2018Q2. The sample period for our analysis covers the years 2009 to 2016. Aggregate housing market statistics are provided by Finans Danmark, the private association of banks and mortgage lenders in Denmark.

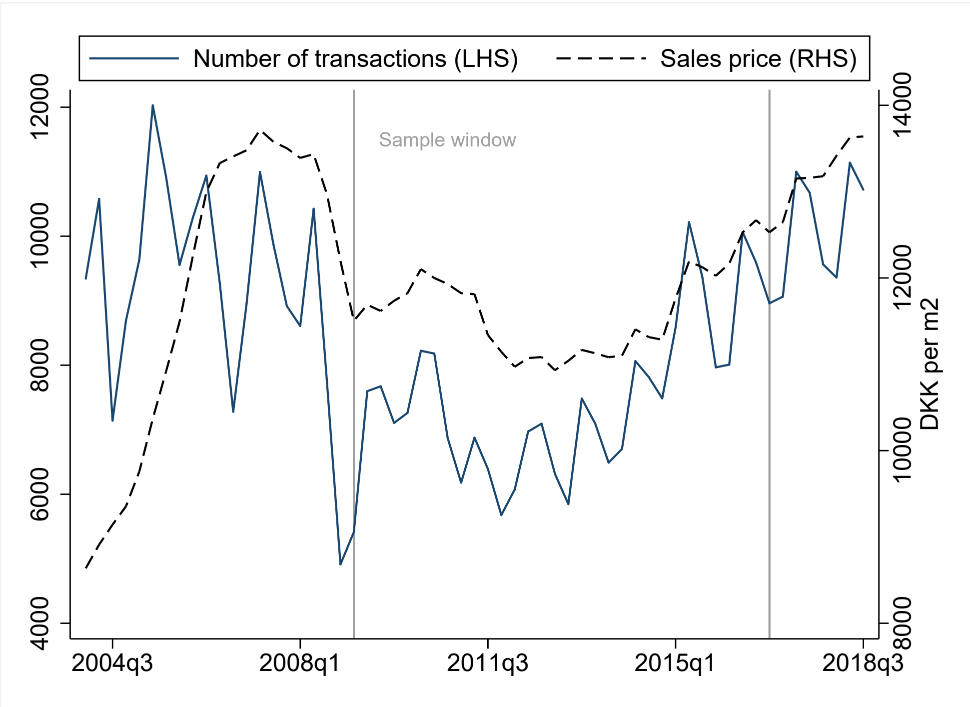
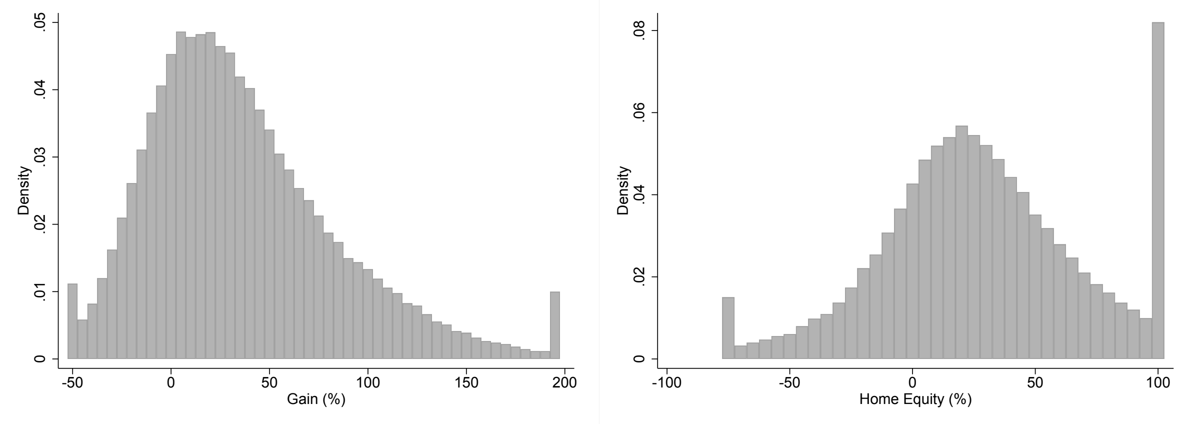


Figure A.3

Summary Statistics: Transaction Characteristics

This figure shows four histograms of main variables of interest. Gain ($\widehat{G}$) is computed as the log difference between the estimated hedonic price ($\widehat{P}$) and the previous purchase price (R), i.e. $\widehat{G} = \ln \widehat{P} - \ln R$, in percent. Home equity ($\widehat{H}$) is computed as the log difference between the estimated hedonic price and the current mortgage value (M), i.e. $\widehat{H} = \ln \widehat{P} - \ln M$, in percent. $\widehat{H}$ is truncated at 100 in order to avoid small mortgage balances leading to log differences greater than 100. The listing premium (ℓ) measures the log difference between the ask price and estimated hedonic price, in percent. All are winsorized at 1 percent in both ends. Time on the market (TOM) measures the time in weeks between when a house is listed and recorded as sold. Each listing spell is restricted to 200 weeks.

Panel A



Panel B

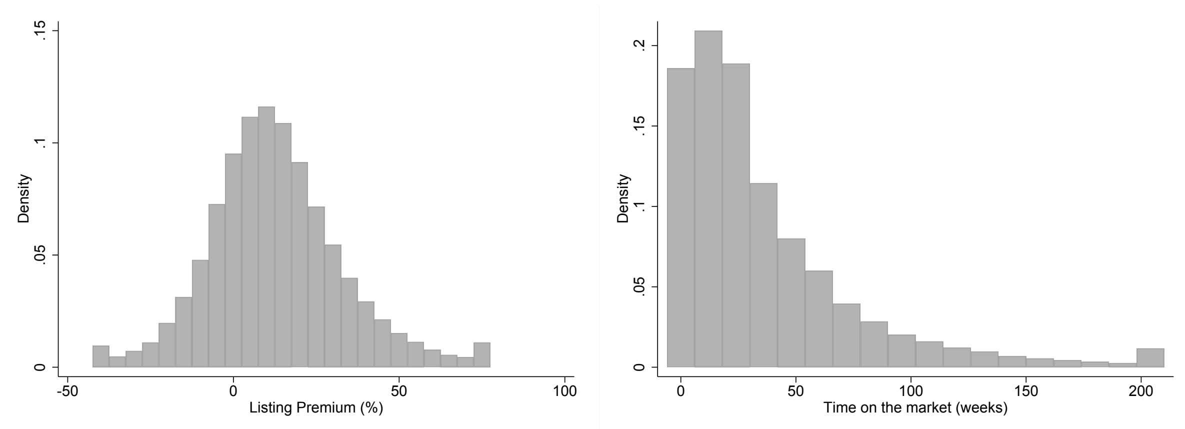
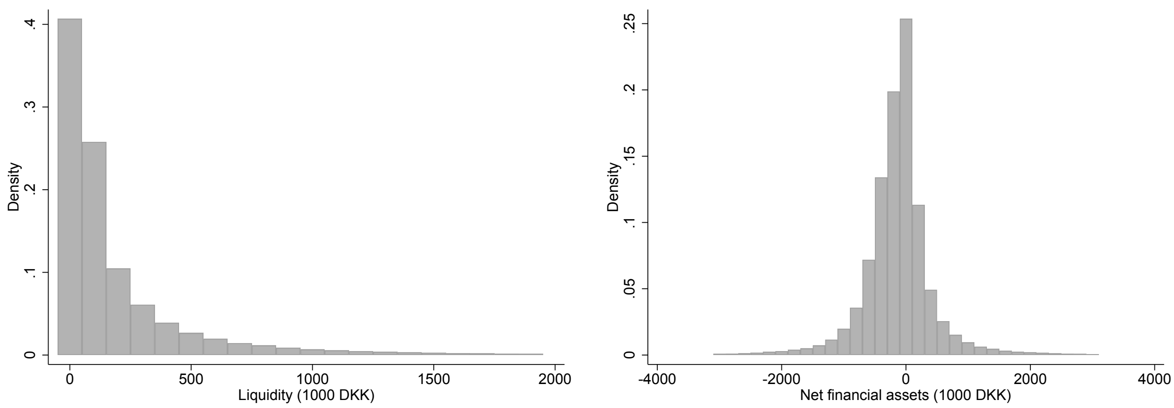


Figure A.4

Summary Statistics: Household Characteristics

This figure shows four histograms of household characteristics. Panel A shows the distribution of available liquid assets. Liquidity is measured as liquid financial wealth (deposit holdings, stocks and bonds). Net financial wealth is measured as liquid financial wealth net of bank debt. Panel B shows household characteristics. Age measures the average age in the household, and education length measures the average length of years spent in education across all adults in the household.

Panel A



Panel B

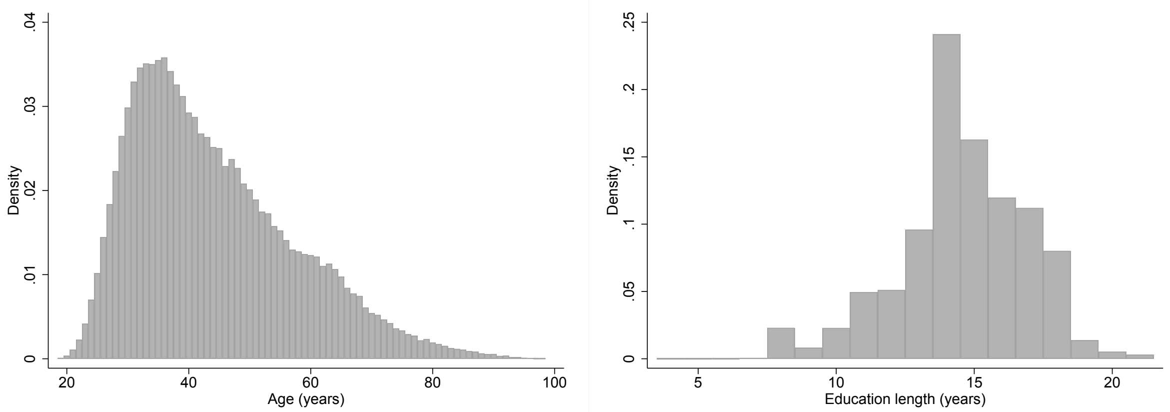


Figure A.5

Actual vs. Predicted Price of Sold Properties

This figure shows a binned scatter plot of the estimated log hedonic price $\ln(P_{it})$ versus the realized log sales price, for the sample of listings that resulted in a sale ($N = 114,897$). The hedonic model is as follows: $\ln(P_{it}) = \xi + \xi_t + \xi_m + \xi_{tm} + \beta_{ft}\mathbb{1}_{i=f}\mathbb{1}_{t=\tau} + \boldsymbol{\beta}\mathbf{X_{it}} + \boldsymbol{\beta_{fx}}\mathbb{1}_{i=f}\mathbf{X_{it}} + \Phi(v_{it}) + \mathbb{1}_{i=f}\Phi(v_{it}) + \varepsilon_{it}$, where $\mathbf{X_{it}}$ is a vector of property characteristics, namely ln(lot size), ln(interior size), number of rooms, number of bathrooms, number of showers, a dummy variable for whether the property was unoccupied at the time of sale or retraction, ln(age of the building), a dummy variable for whether the property is located in a rural area, a dummy for whether the building registered as historic, and ln(distance of the property to the nearest major city). ξ is a constant, ξ_t are year fixed effects, ξ_m are fixed effects for different municipalities (98 municipalities in total), and $\mathbb{1}_{i=f}$ is an indicator variable for whether the property is an apartment (denoted by f for flat) rather than a house. $\Phi(v_{it})$ is a third-order polynomial of the previous-year tax assessor valuation of the property. The R^2 of the regression is 0.88.

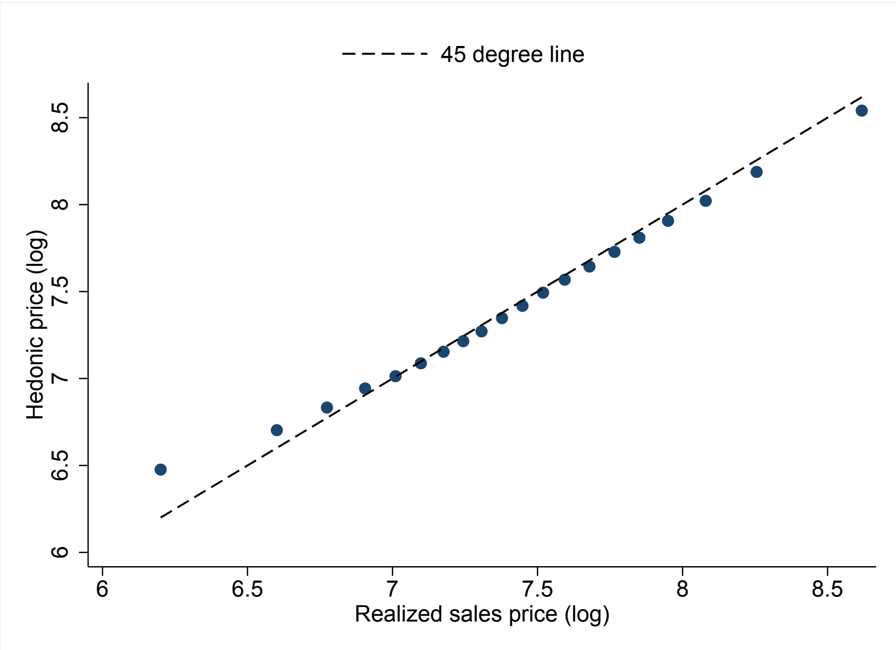


Figure A.6

Gains and Home Equity

This figure plots the joint distribution of the experienced gain and home equity position of households, at the time of listing. The color scheme refers to the relative frequency of observations in gain and home equity bins of 10 percentage points, where each color corresponds to a decile in the joint frequency distribution. The darker shading indicates a higher density of observations. Gain-home equity bins that did not have sufficient observations are shaded in white. The dotted blue lines separate the joint distribution in four groups: (1) Unconstrained Winners ($\widehat{H}$ ≥20% and $\widehat{G}$ ≥0) covering 48.8% of the sample, (2) Constrained Winners ($\widehat{H}$ <20% and $\widehat{G}$ ≥0) with 26.5%, (3) Unconstrained Losers ($\widehat{H}$ ≥20% and $\widehat{G}$ <0) with 6.2%, and (4) Constrained Losers ($\widehat{H}$ <20% and $\widehat{G}$ <0) accounting for 18.6% of the sample.

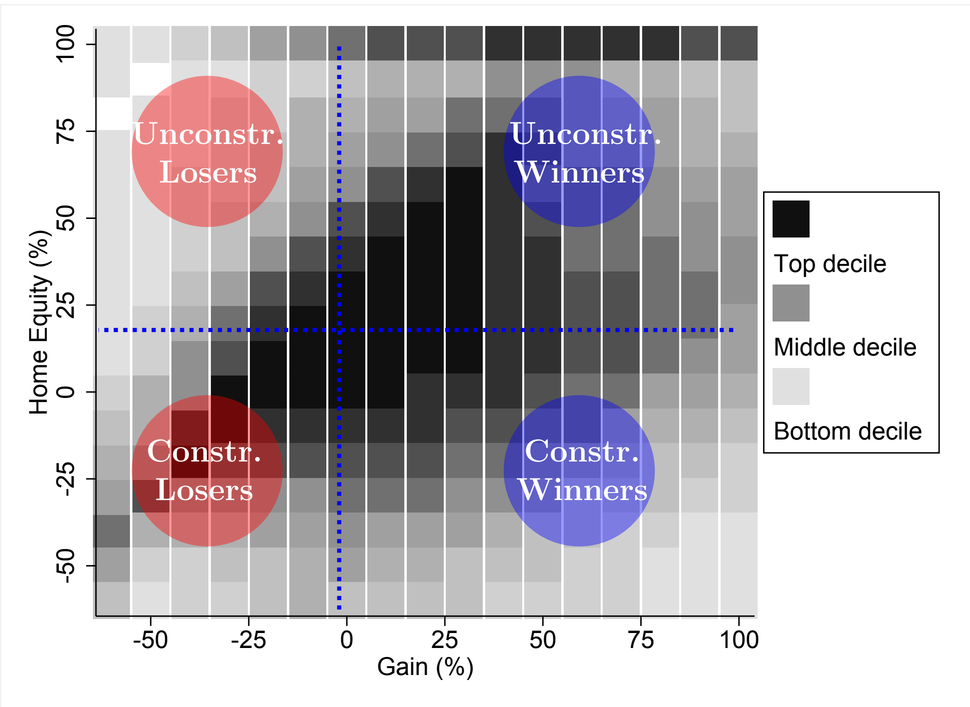


Figure A.7
Seller Groups - Listed (Relative Shares)

This figure shows the relative share of each seller group over time. The four groups are defined as follows: I) Unconstrained Winners ($\widehat{H}$ ≥20% and $\widehat{G}$ ≥0), II) Constrained Winners ($\widehat{H}$ <20% and $\widehat{G}$ ≥0), III) Unconstrained Losers ($\widehat{H}$ ≥20% and $\widehat{G}$ <0), IV) Constrained Losers ($\widehat{H}$ <20% and $\widehat{G}$ <0).

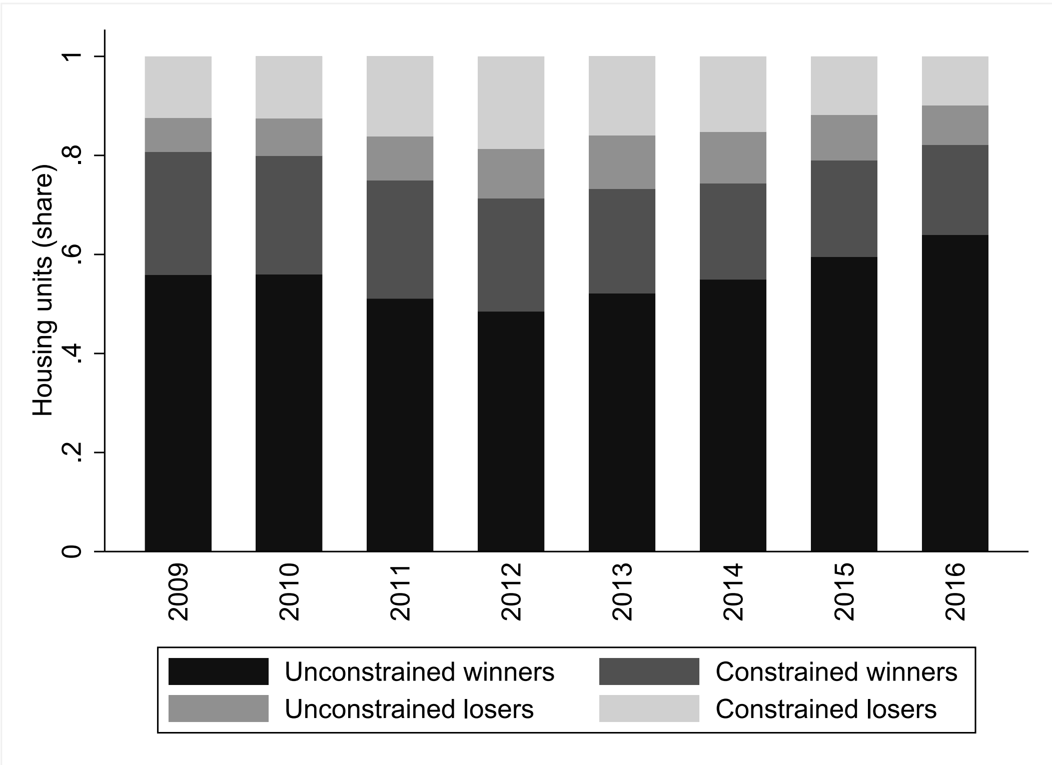


Figure A.8
Loss Aversion: Understanding Heterogeneity

This figure shows the effect of experienced gains on the ask-market-premium (AMP) across quantile bins of covariates (age, education length and net financial wealth). It reports estimated coefficients across different bins of covariates, which corresponds to the slope across the loss domain ($\widehat{G} < 0$), conditional on additional controls for home equity, and time and municipality fixed effects. The sign for $\beta_1 + \beta_3$ is reversed such that an increase in the coefficient can be read as an increase in the effect.

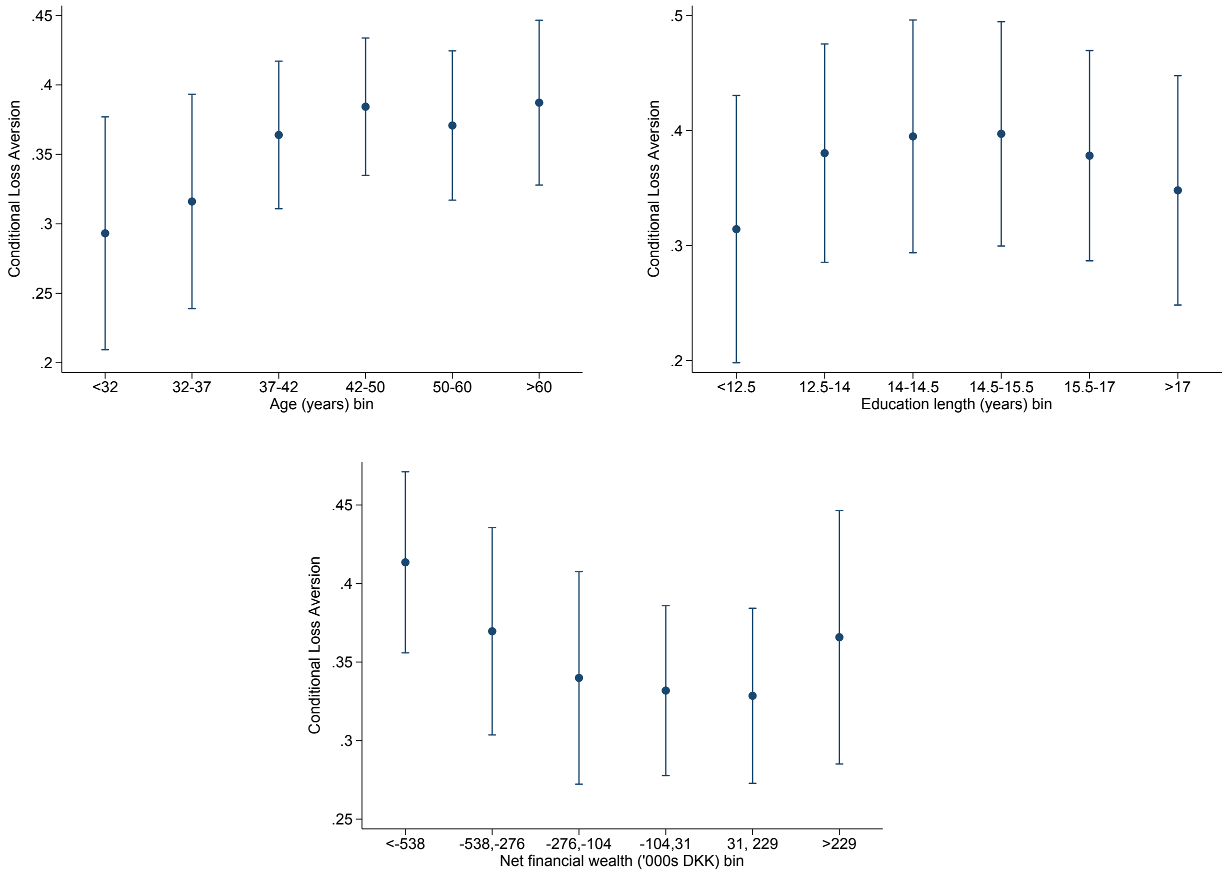


Figure A.9

Down-Payment Constraints: Understanding Heterogeneity

This figure shows the effect of home equity on the ask-market-premium (AMP) across quantile bins of covariates (age, education length, and net financial wealth). It reports the estimated coefficients across different bins of covariates, which corresponds to the slope across the constrained domain ($\widehat{H} < 20\%$), conditional on additional controls for experienced gains, and time and municipality fixed effects. The sign for $\gamma_1 + \gamma_3$ is reversed such that an increase in the coefficient can be read as an increase in the effect.

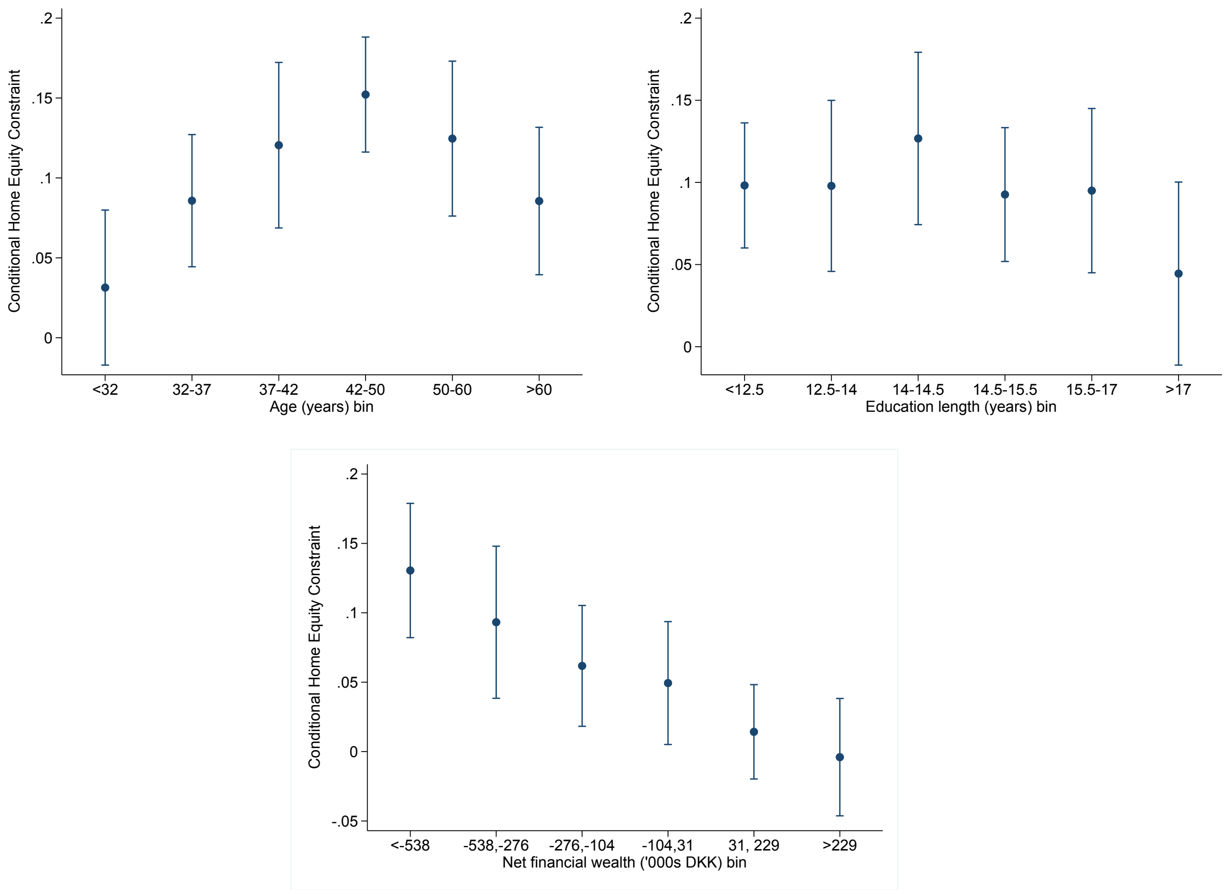


Figure A.10
Time-on-the-market and retraction rate

This figure shows the relationship between (a) time-on-market, and (b) the retraction rate for different levels of the listing premium.

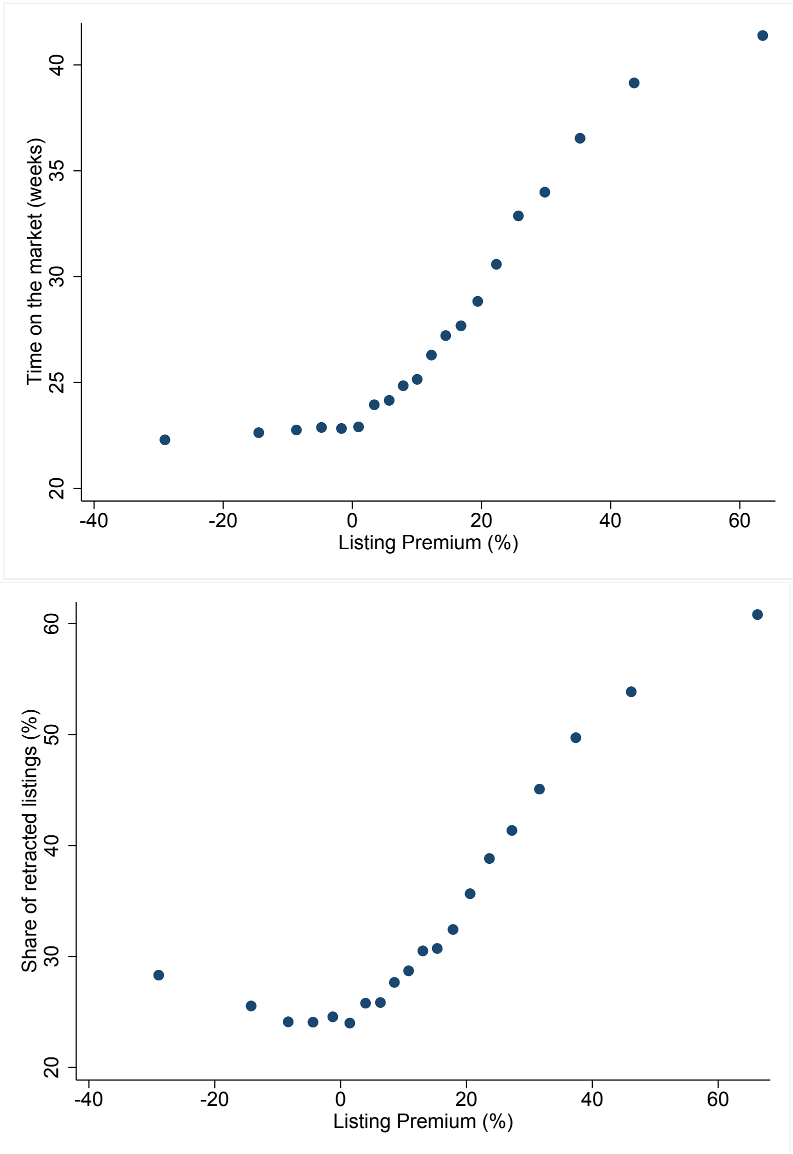


Figure A.11

Estimation of Generalized Logistic Functions (GLF)

This figure shows the effect of experienced gains (Panel A) and home equity (Panel B) on the listing premium. We report estimated relationships which follow a non-linear model specified in the form of a generalized logistics function $E[AMP(V)] = A + \frac{K-A}{(1+Qe^{-BV})^{1/\nu}}$, for which the underlying parameters A, K, Q, B, ν are estimated through a non-linear least squares procedure, and the assignment variables are $V = \widehat{G}$ and $V = \widehat{H}$ respectively. The solid dots indicate bin scatter points, for equally spaced bins of experienced gains and home equity.

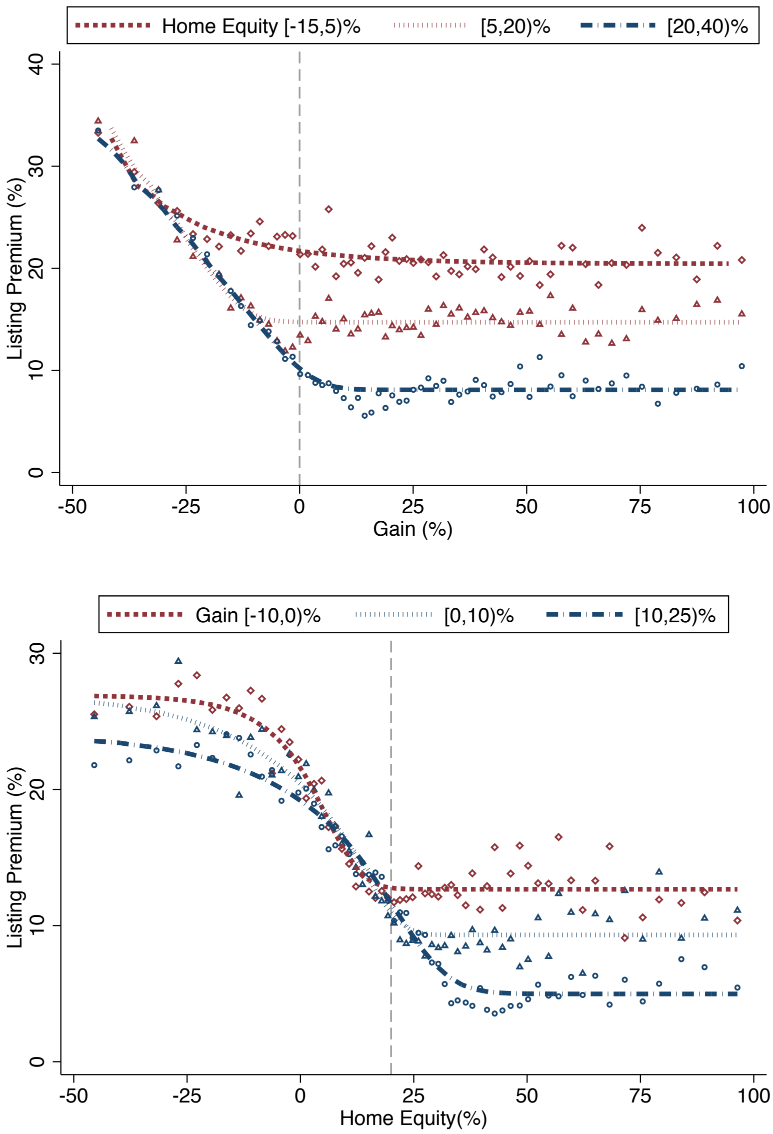


Figure A.12

Coverage of Alternative Models of $\widehat{P}$

This graph shows the number of observations for which we can estimate $\widehat{P}$ for different alternative models. *Hedonic* is a comprehensive hedonic model and our baseline specification. *Ext. hedonic* is an extended version of *Hedonic* which adds purchase year fixed effects and interacts all hedonic controls with three dummies for interior size. *Repeat* adds property fixed effects to *Hedonic* and is therefore restricted to repeated sales within the sample. *Mun. index* is the purchase price adjusted for local, i.e. municipality level, price changes and *Shire index* is the purchase price adjusted for local, shire level, price changes. If not indicated otherwise, models are estimated on the final sample of (repeated) sales from 2009 to 2016. If (full) is indicated, the model is estimated on the full sample of (repeated) sales from 1992 to 2016. *Repeat* > 2*(full)* is restricted to properties sold at least three times during the full sample period.

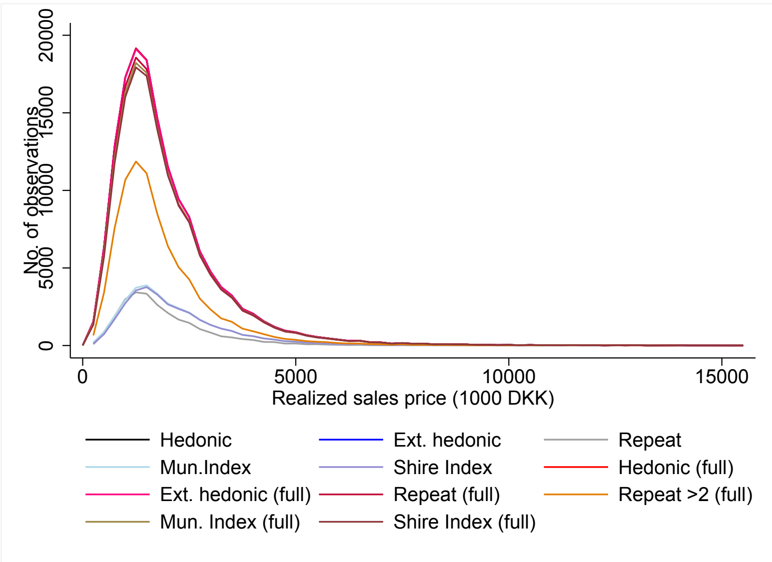
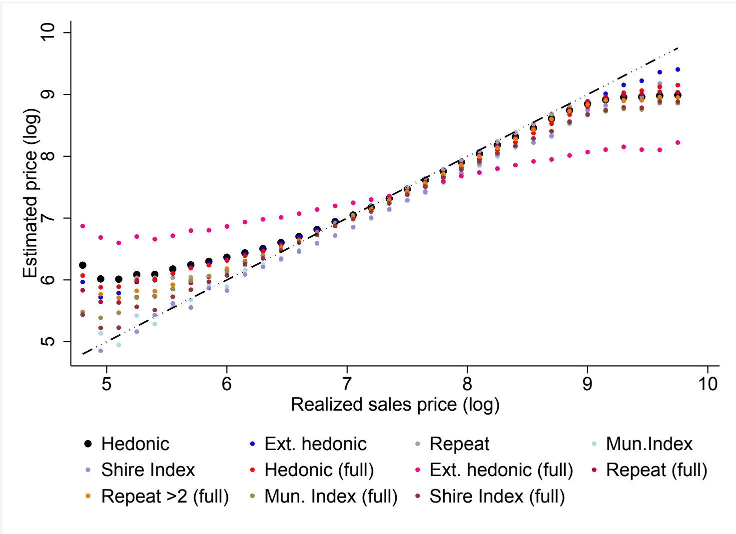


Figure A.13

Estimated vs. Realized ln(price)

This graph compares the model estimated price to the realized sales price in logs. *Hedonic* is a comprehensive hedonic model, and the baseline model for our main analysis. *Ext. hedonic* is an extended version of *Hedonic* which adds purchase year fixed effects and interacts all hedonic controls with three dummies for interior size. *Repeat* adds property fixed effects to *Hedonic* and is therefore restricted to repeated sales within the sample. *Mun. index* is the purchase price adjusted for local, municipality level, price changes and *Shire index* is the purchase price adjusted for local, shire level, price changes. If not indicated otherwise, models are estimated on the final sample of (repeated) sales from 2009 to 2016. If (full) is indicated, the model is estimated on the full sample of (repeated) sales from 1992 to 2016. *Repeat* $>$ 2*(full)* is restricted to properties sold at least three times during the full sample period.

Panel A: All



Panel B: Below 5 mil. DKK

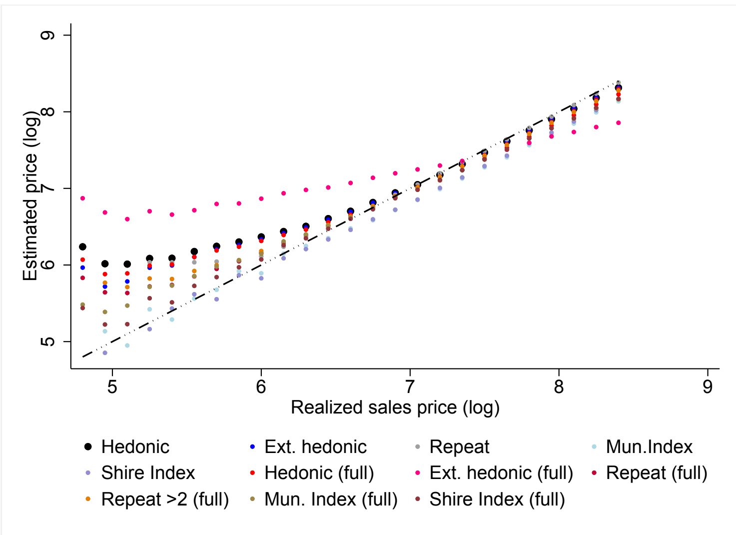
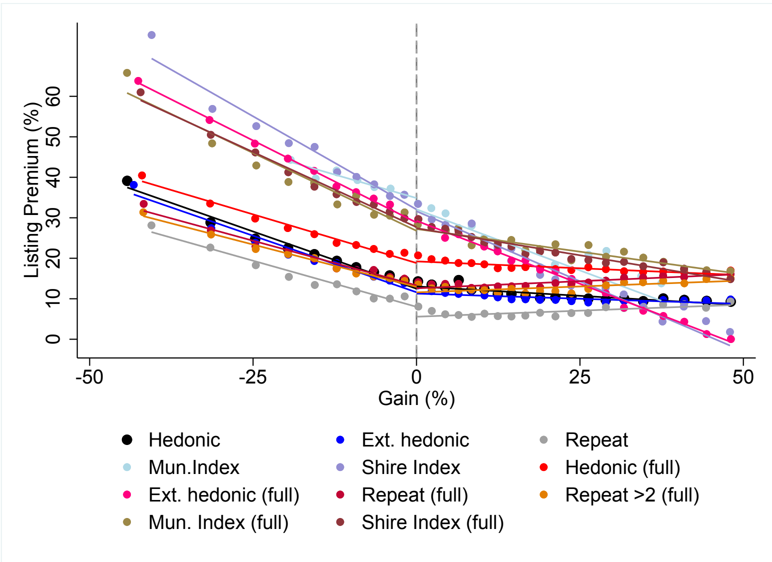


Figure A.14
Robustness to Alternative Models of $\widehat{P}$

These figures show the robustness of our two key empirical shapes to alternative specifications of $\widehat{P}$. Panel A show the listing price-to-gains relationship and Panel B shows demand concavity. *Hedonic* is a comprehensive hedonic model, and the baseline model for our main analysis. *Ext. hedonic* is an extended version of *Hedonic* which adds purchase year fixed effects and interacts all hedonic controls with three dummies for interior size. *Repeat* adds property fixed effects to *Hedonic* and is therefore restricted to repeated sales within the sample. *Mun. index* is the purchase price adjusted for local, municipality level, price changes and *Shire index* is the purchase price adjusted for local, shire level, price changes. If not indicated otherwise, models are estimated on the final sample of (repeated) sales from 2009 to 2016. If (full) is indicated, the model is estimated on the full sample of (repeated) sales from 1992 to 2016. *Repeat* > 2*(full)* is restricted to properties sold at least three times during the full sample period.

Panel A



Panel B

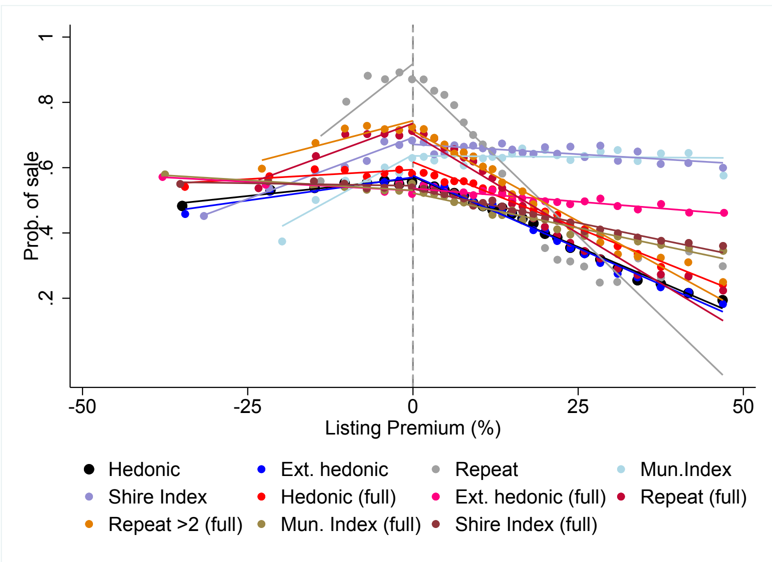
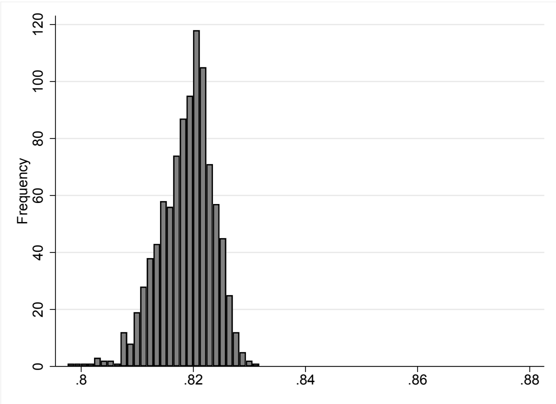


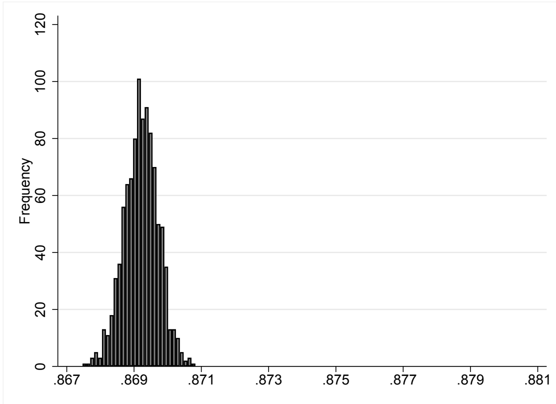
Figure A.15
Distribution of R^2s from out-of-sample estimation of the hedonic model

These figures show the distribution of R^2 from 1000 regressions of realized price on out-of-sample-predicted hedonic prices. Notice the different range of the x-axis in Panel (a) relative to the other panels. In addition, Panel (a) is cropped at 0.79, but in 29 of the regressions, the R^2 was less and in most cases very close to 0, reflecting the vulnerability of a 1 percent sample

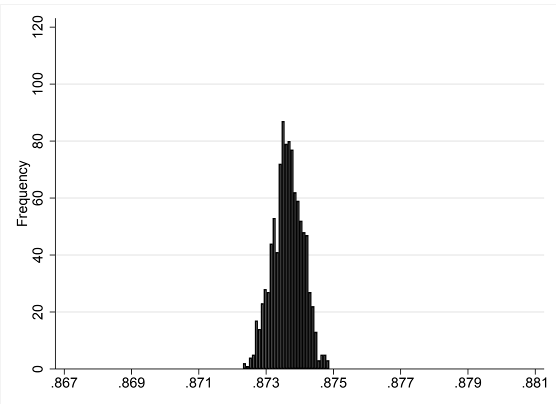
(a) 1 percent sample



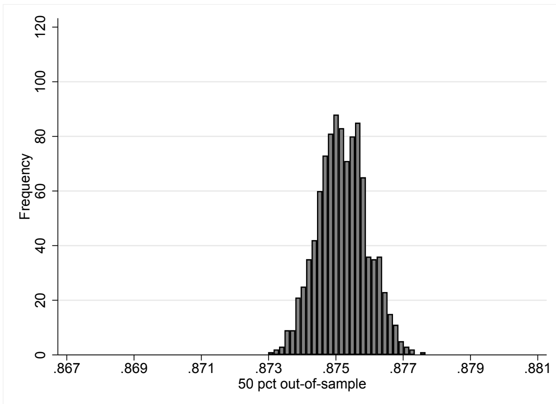
(b) 10 percent sample



(c) 25 percent sample



(d) 50 percent sample



(e) 75 percent sample

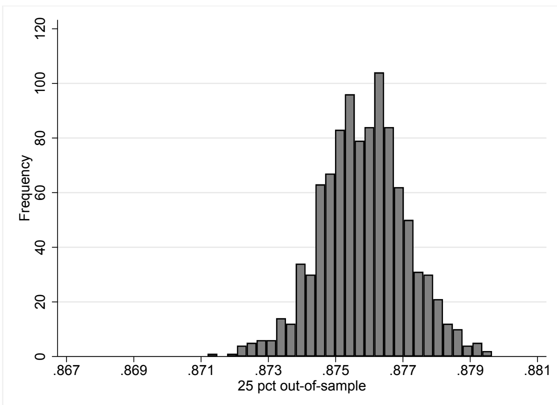
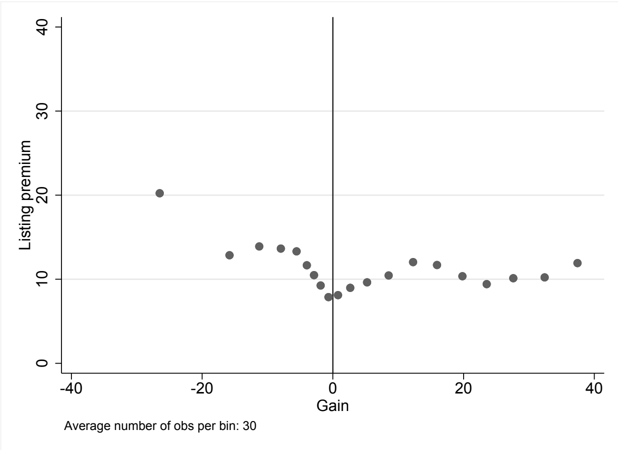


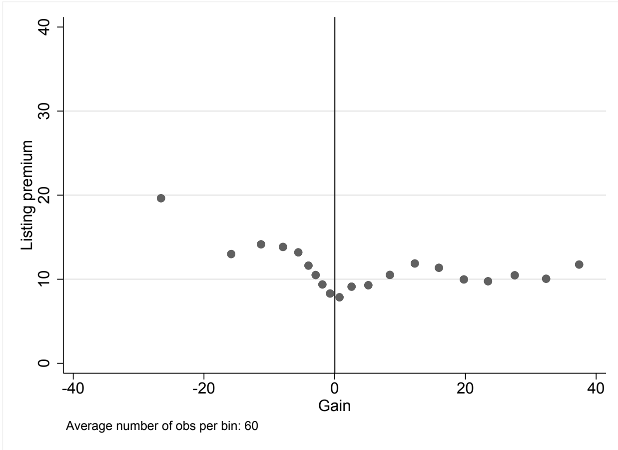
Figure A.16
Listing premium vs. gain at home equity around 20 - out-of-sample predictions

Home equity is between 18 and 22 percent. Notice that the samples are only fractions of sold houses and the sellers have positive mortgage. Bins are averages of 1000 iterations

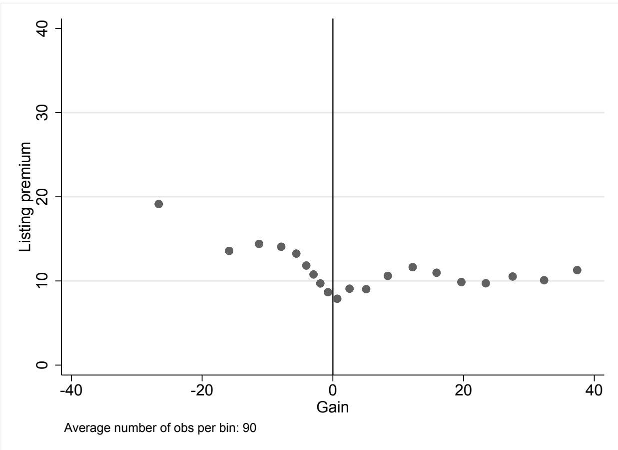
(a) 25 percent out of sample



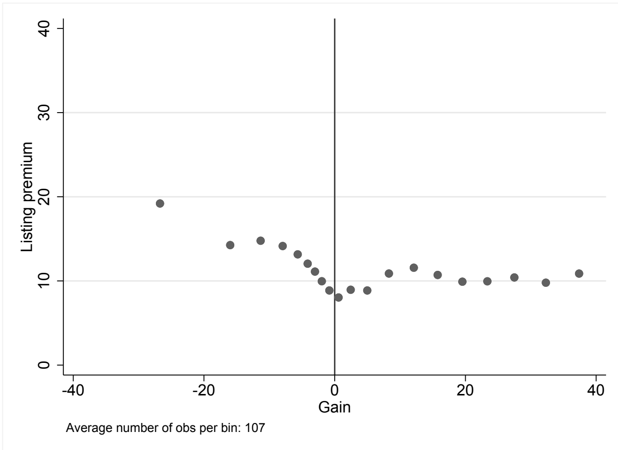
(b) 50 percent out of sample



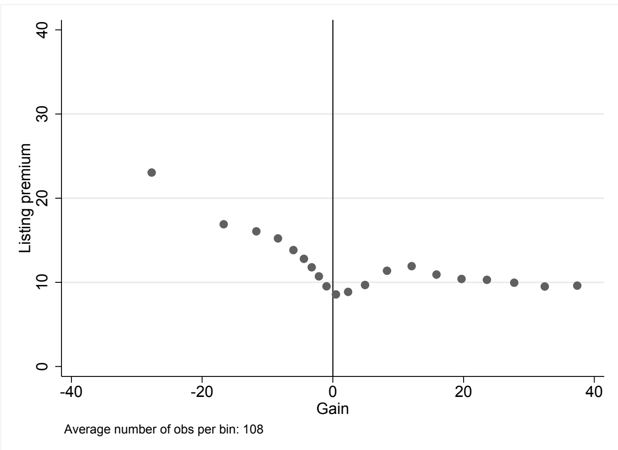
(c) 75 percent out of sample



(d) 90 percent out of sample



(e) 1 percent out of sample



(f) Main data, only sales

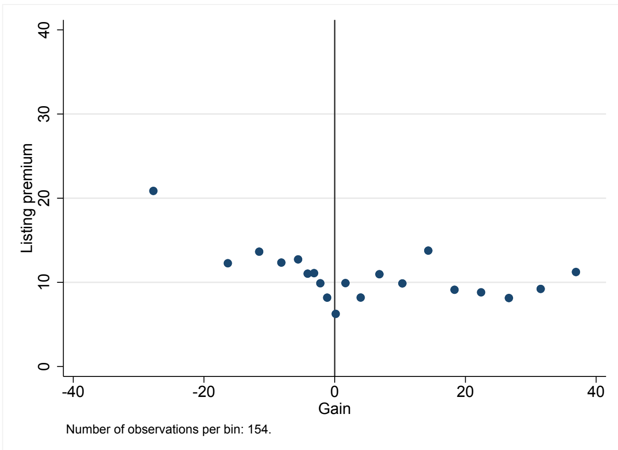
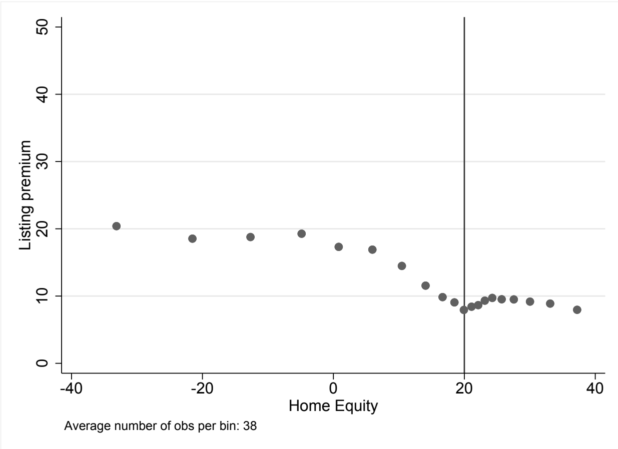


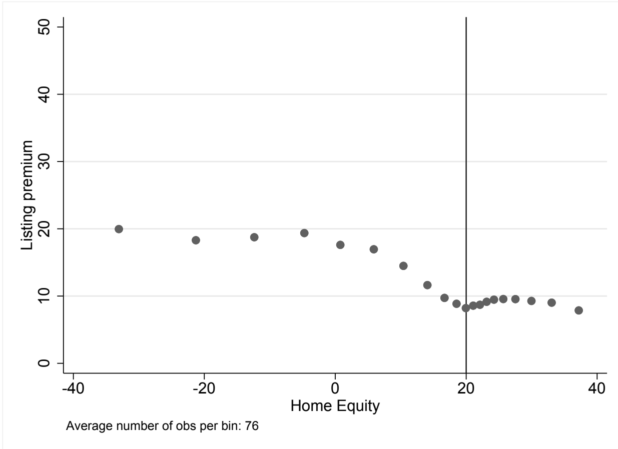
Figure A.17
Listing premium vs. home equity at gain around 0 - out-of-sample predictions

Gain is between -2 and 2 percent. Notice that the samples are only fractions of sold houses and the sellers have positive mortgage. Bins are averages of 1000 iterations

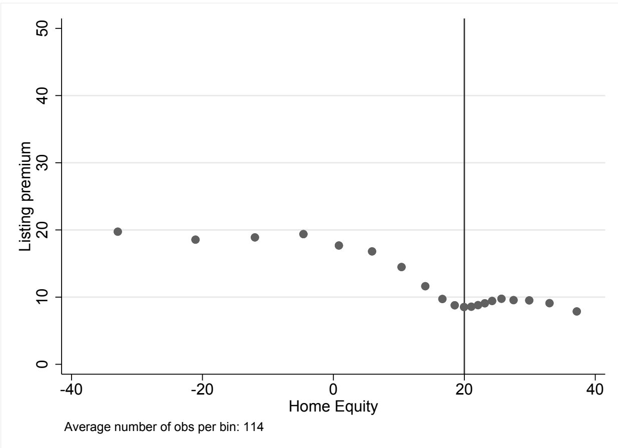
(a) 25 percent out of sample



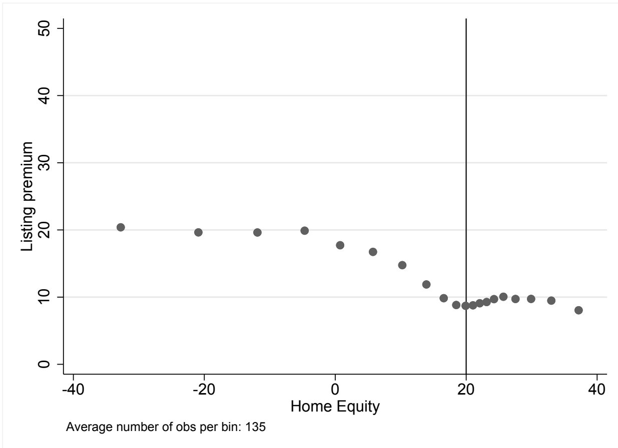
(b) 50 percent out of sample



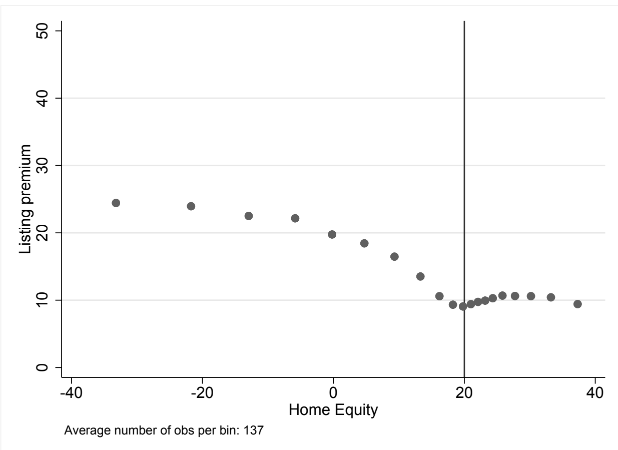
(c) 75 percent out of sample



(d) 90 percent out of sample



(e) 99 percent out of sample



(f) Main data, only sales

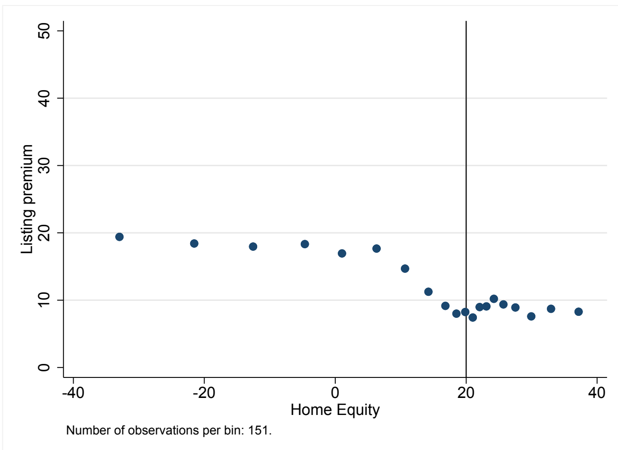
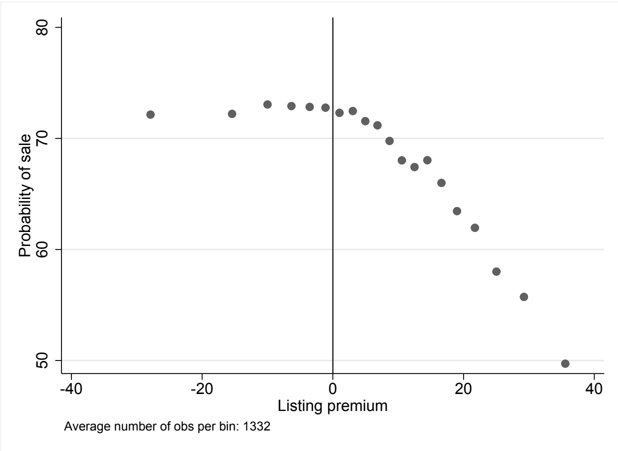


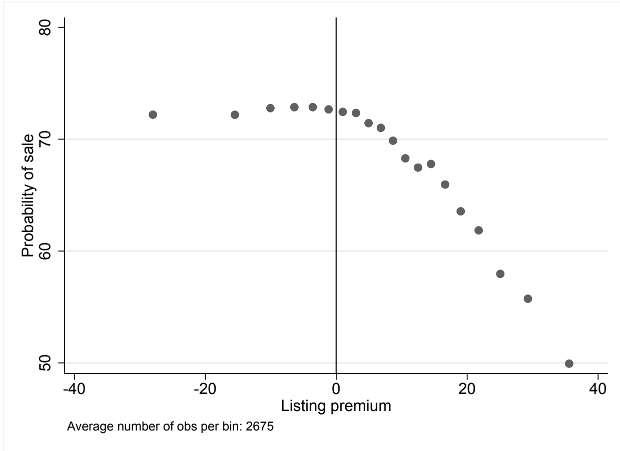
Figure A.18
Prob. of sale vs. listing premium - out-of-sample predictions

Notice that the samples are only fractions of sold houses and the sellers have positive mortgage. Bins are averages of 1000 iterations. Probability of sales refers to the probability of sale within 6 months.

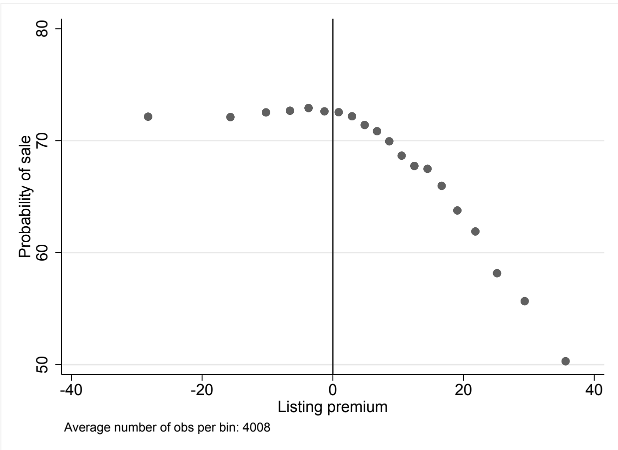
(a) 25 percent out of sample



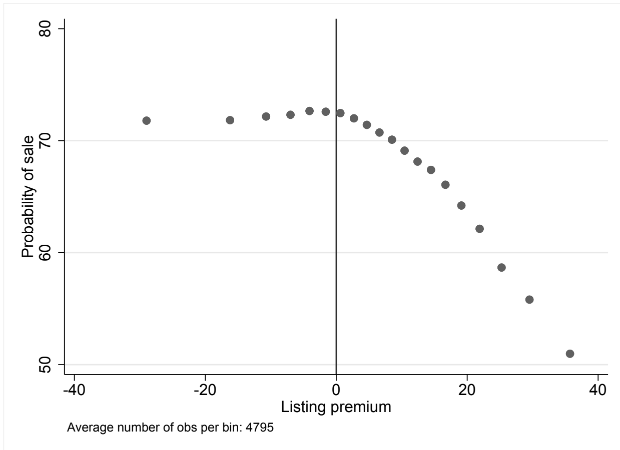
(b) 50 percent out of sample



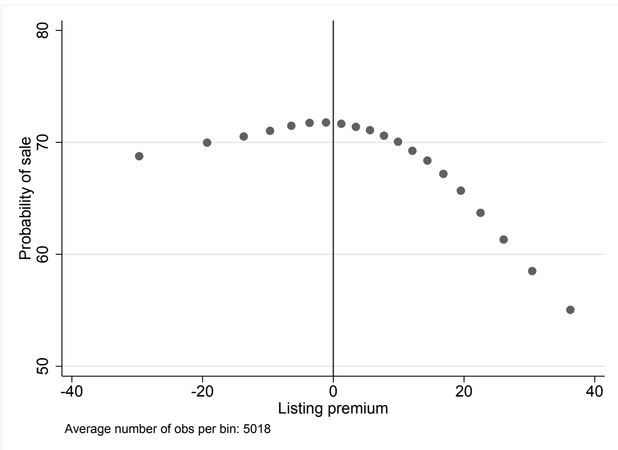
(c) 75 percent out of sample



(d) 90 percent out of sample



(e) 99 percent out of sample



(f) Main data, only sales

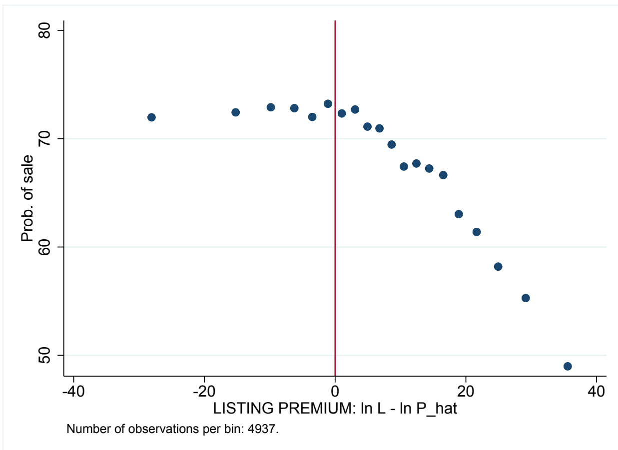
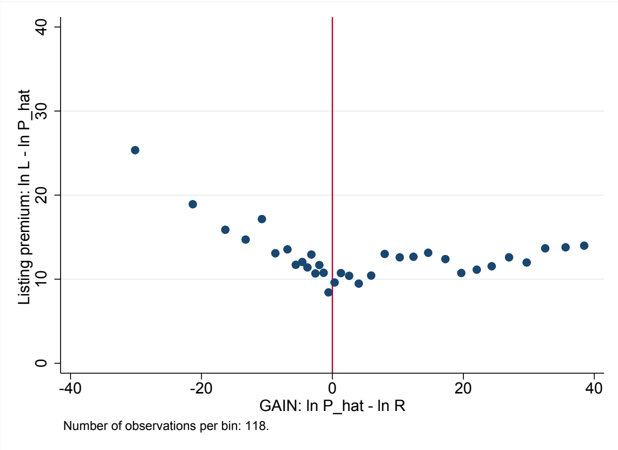


Figure A.19
Listing premium vs. gain at home equity around 20 %

Home equity is between 18 and 22 percent. Panel (b) is restricted to 2010-2012, since this is when tax-assessment is most accurate.

(a) Standard hedonic model



(b) Tax assessed value

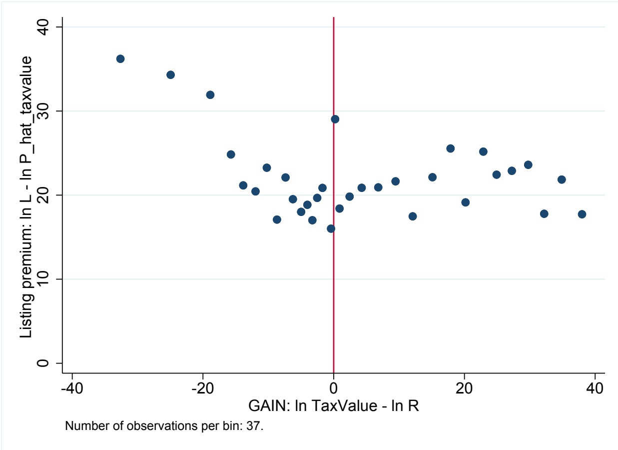
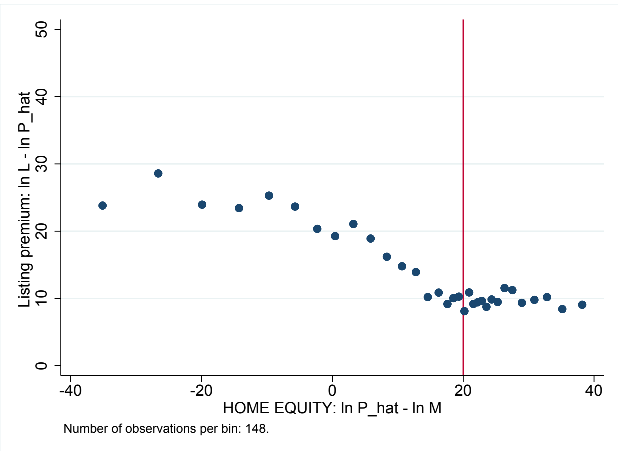


Figure A.20
Listing premium vs. home equity at gain around 0

Gain is between -2 and 2 percent. Panel (b) is restricted to 2010-2012, since this is when tax-assessment is most accurate.

(a) Standard hedonic model



(b) Tax assessed value

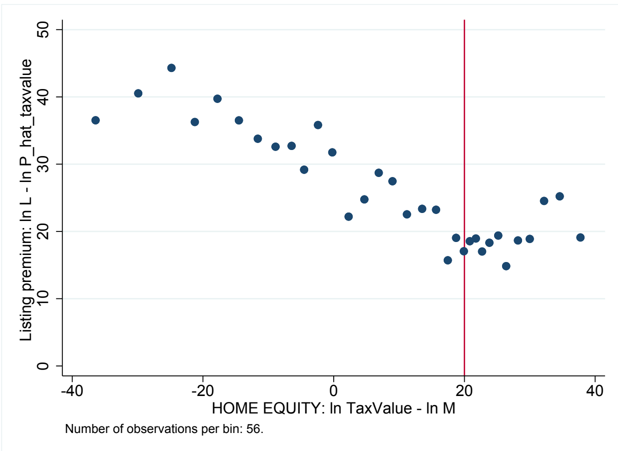


Figure A.21
Probablity of sale vs. listing premium

Panel (b) is restricted to 2010-2012, since this is when tax-assessment is most accurate.

(a) Standard hedonic model **(b)** Tax assessed value

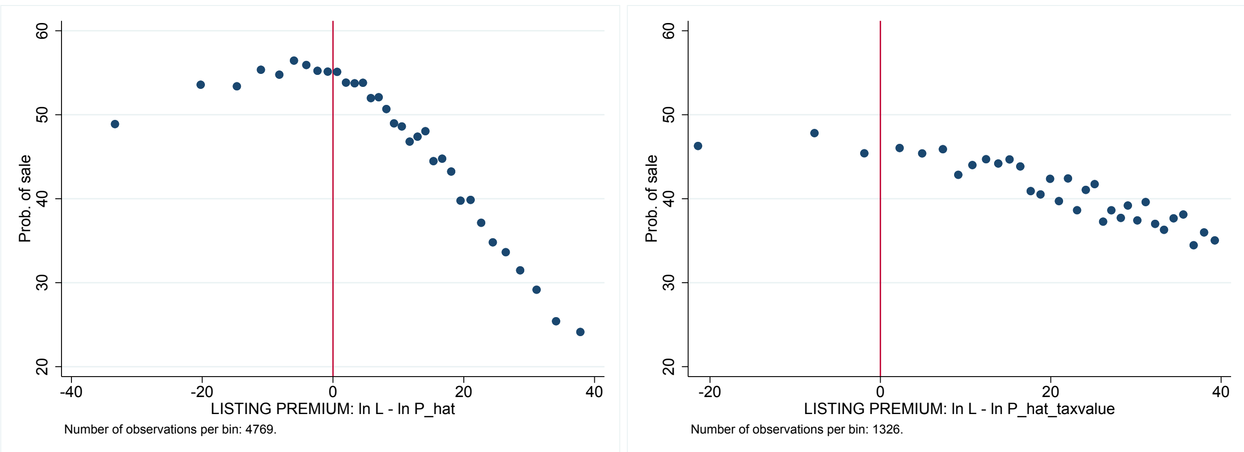
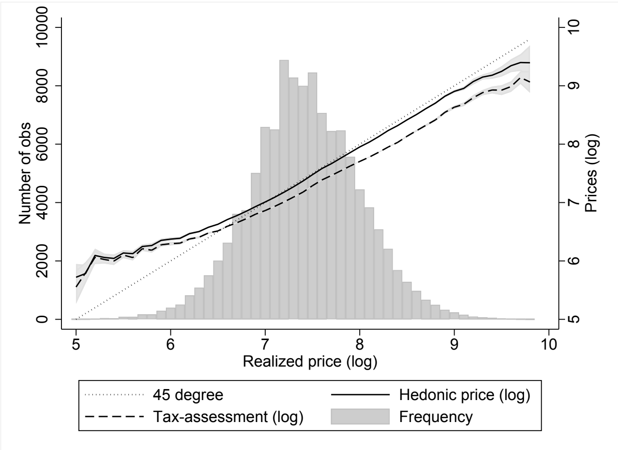


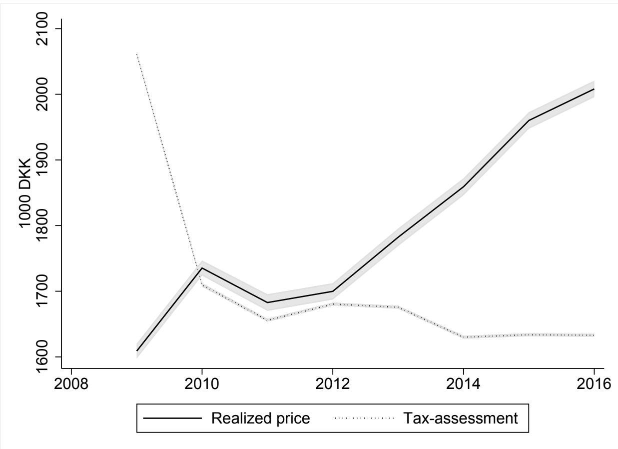
Figure A.22
Quality of the tax-assessed value

Panel (a) shows the tax-assesment relative to the realised sales price as well as the distribution of prices. Panel (b) compares the tax-assessed value to the realised sales prices over our sample period. Panel (c) expands the time period. Data in (a) is the final data of mortgage-holding households from 2009 to 2016. Data in (b) and (c) applies less filters, because they cannot be applied in all years. E.g does it also contains no-mortgage households, since we do not have mortgage data prior to 2009.

(a) Hedonic price vs. tax-assesment



(b) Realized price and tax-assesment by year.



(c) Realized price and tax-assesment by year.

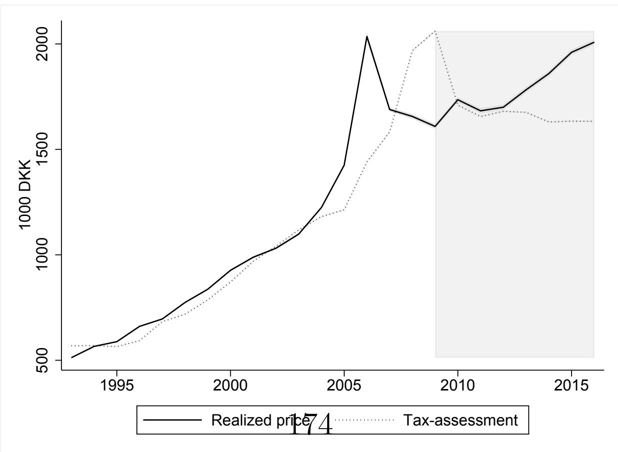


Figure A.23

Residual Listing Premium and Gains and Home Equity

This figure shows the relationship between residual listing premium and gains or home equity, respectively. The residual listing premium is computed with household controls (age, education length, net financial assets) and municipality and year fixed effects partialled out.

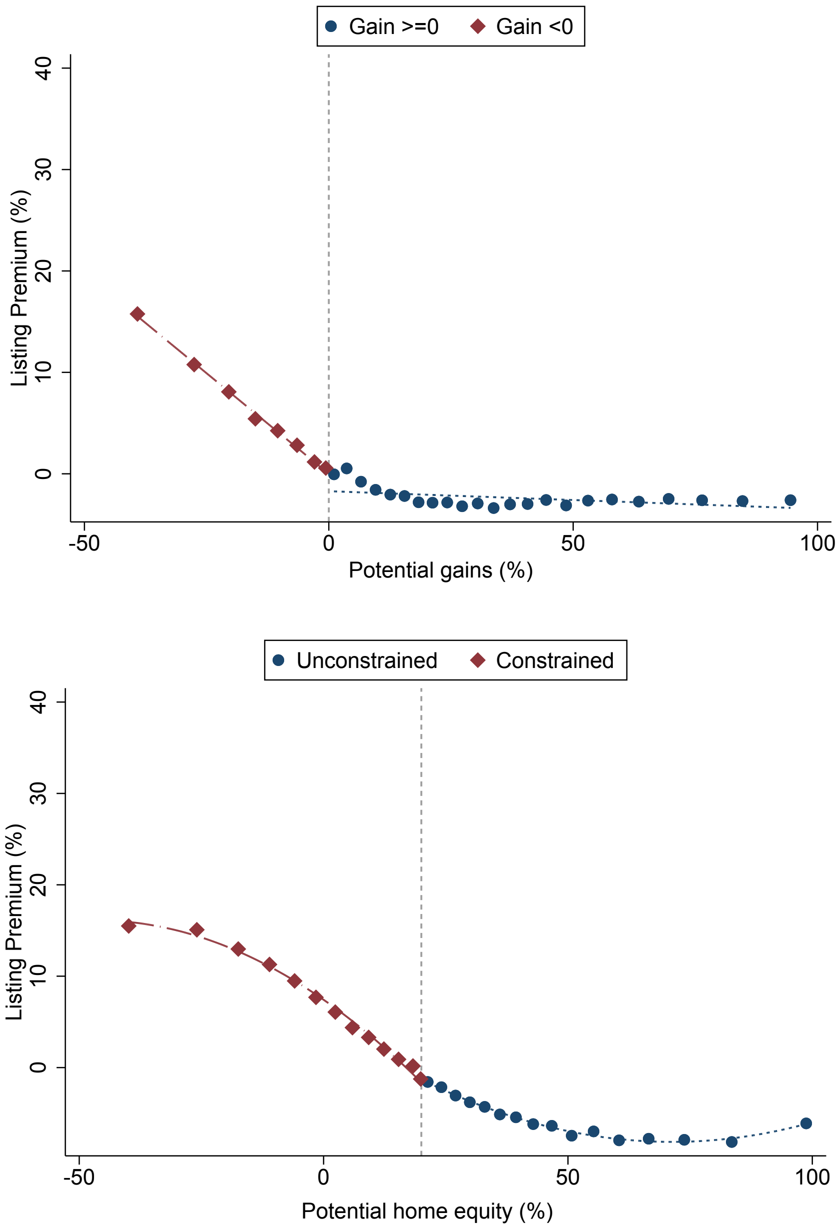


Figure A.24

RKD Validation: Smooth Density of Assignment Variable

This figure shows the number of observations in bins of the assignment variable, gain. Following Landais (2015), the results for the McCrary (2008) test for continuity of the assignment variable and a similar test for the continuity of the derivative are further shown on the figure. We cannot reject the null of continuity of the derivative of the assignment variables at the kink at the 5% significance level.[14]

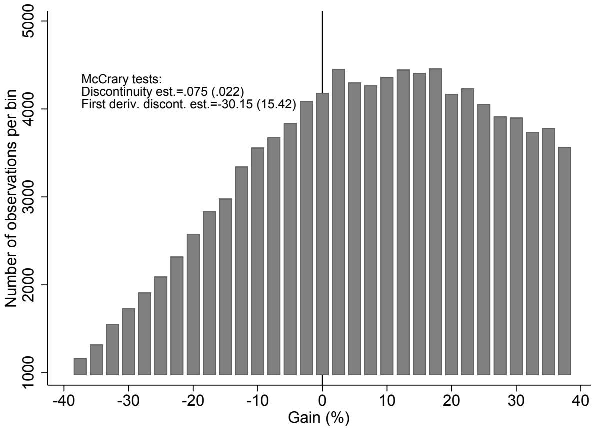


Figure A.25

RKD Validation: Covariates Smooth around Cutoff

This figure shows binned means of covariates (home equity/gain, age, length of education, liquidity, bank debt, financial wealth) over bins of the assignment variable, gain. It provides visual evidence for these covariates evolving smoothly around and not having a kink at the cutoff point.

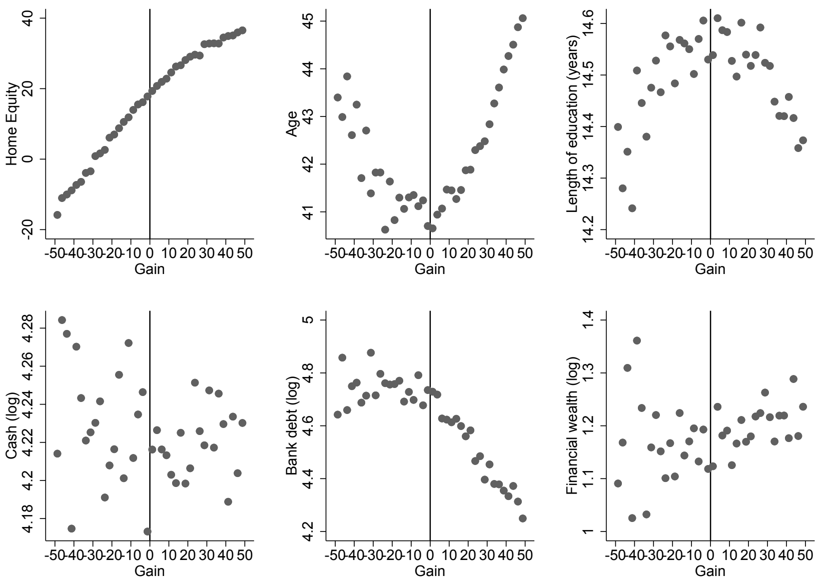


Figure A.26

RKD Robustness: Estimates for Different Bandwidths (Gain)

This figure plots the range of RKD estimates and 95% confidence intervals across bandwidths ranging from 5 to 50, using a local quadratic regression. The optimal bandwidth is indicated based on the MSE-optimal bandwidth selector from Calonico et al. (2014).

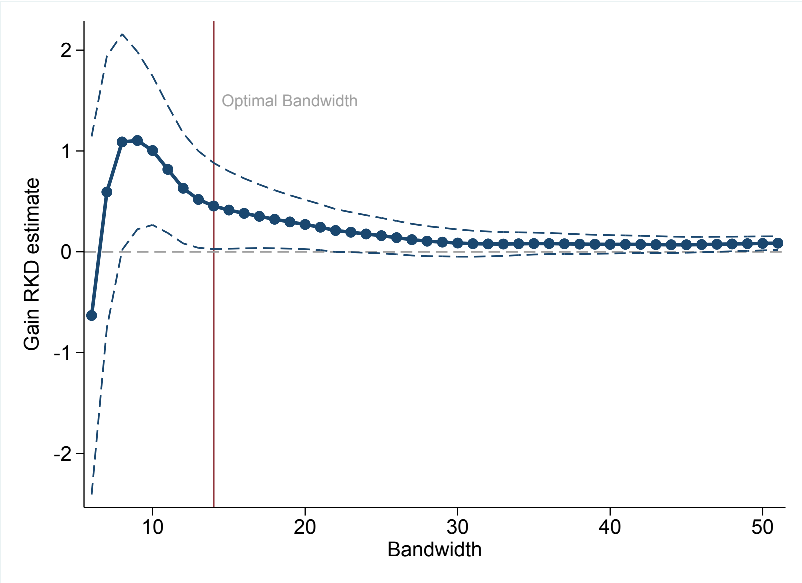


Figure A.27

RKD Estimation: Local Linear vs. Local Quadratic Estimation Results

This figure compares RK estimates using a local linear regression with estimates using a local quadratic regression, across different bandwidths $b \in \{b^*, 10, 20\}$, for gain (G) and probability of sale (P), respectively. b^* refers to the MSE-optimal bandwidth selector from Calonico et al. (2014).

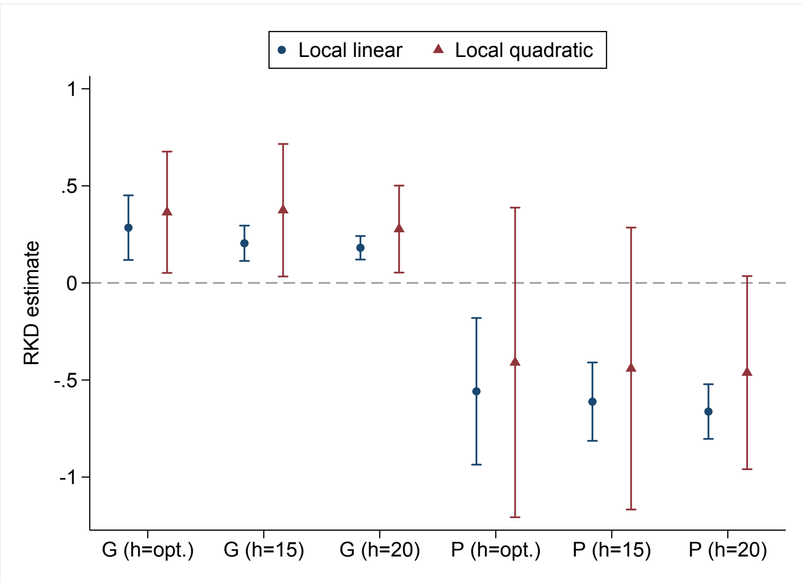


Figure A.28

Non-Mortgage Sample

This figure shows the relationship between listing premium and gains for the sample of households with no mortgage ($N = 41,382$), using a binned scatter plot of equal-sized bins for $\widehat{G} \in [-50, 50]$.

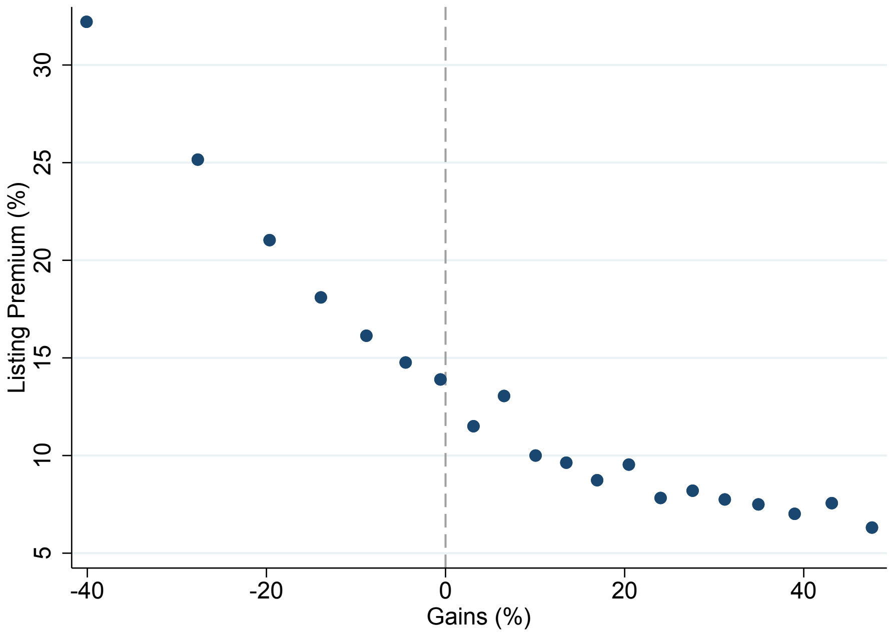


Figure A.29

Correlation between $\alpha(\ell)$ and $P(\ell)$ Levels

This figure shows the correlation between the level of the relationship between probability to sale as a function of the listing premium ($\alpha(\ell)$) on the x-axis and the level of the mapping between listing prices and realized prices ($P(\ell)$) on the y-axis across markets segmented by municipality.

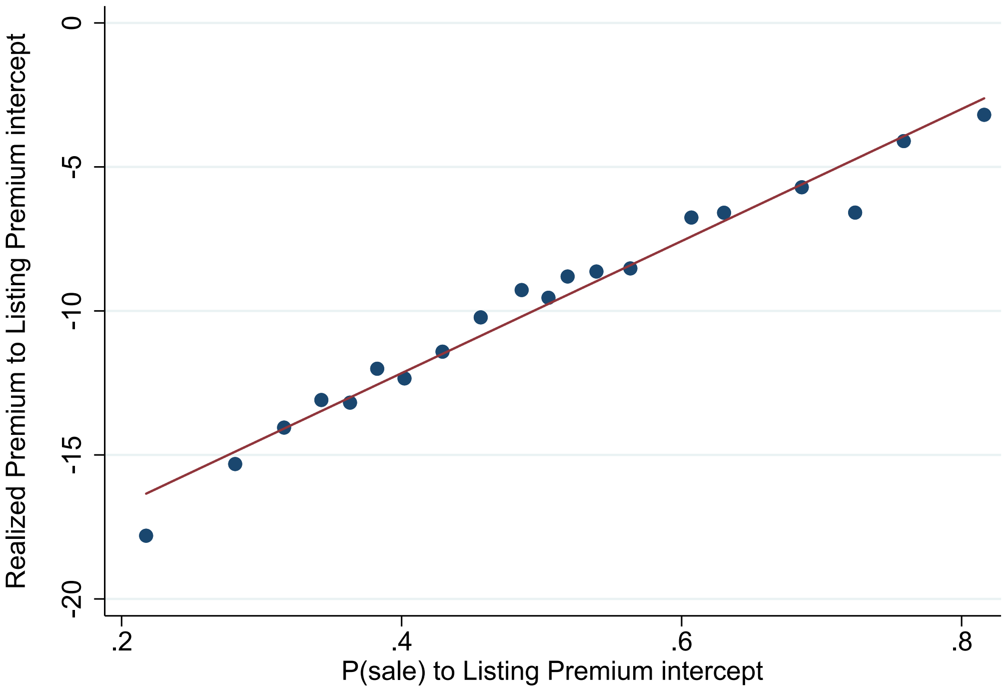


Figure A.30

Listing Premium Predicts Down-Payment

This figure shows a binned scatter plot of the ask-market-premium against the down-payment of a seller's next house, controlling for current home equity ($\widehat{H}$), based on a sub-sample of the data for which we have information on the next house purchase price and mortgage value ($N = 14,440$).

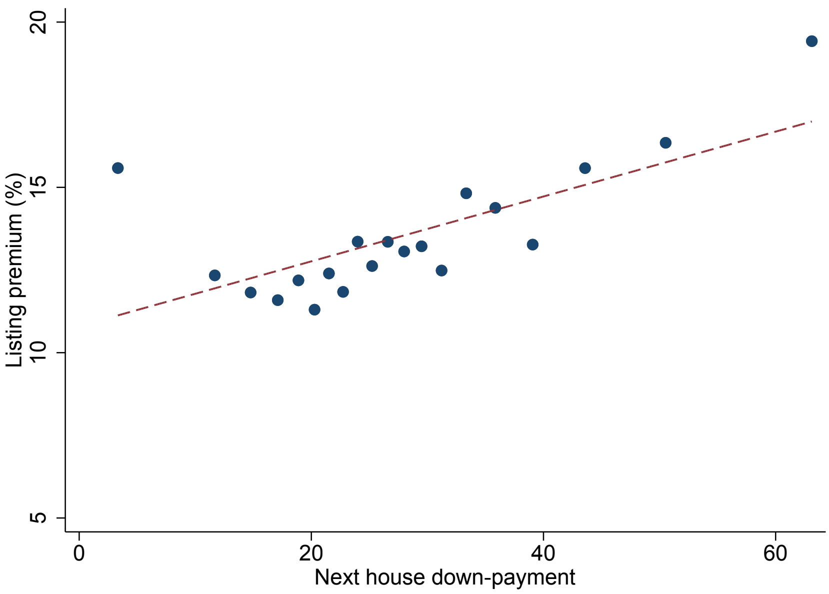


Figure A.31
Current and Next House Price

This figure shows a binned scatter plot of the current home price against the next house price (in 2015 DKK), based on a sub-sample of the data for which we have information on the next house purchase price and mortgage value ($N = 14,440$).

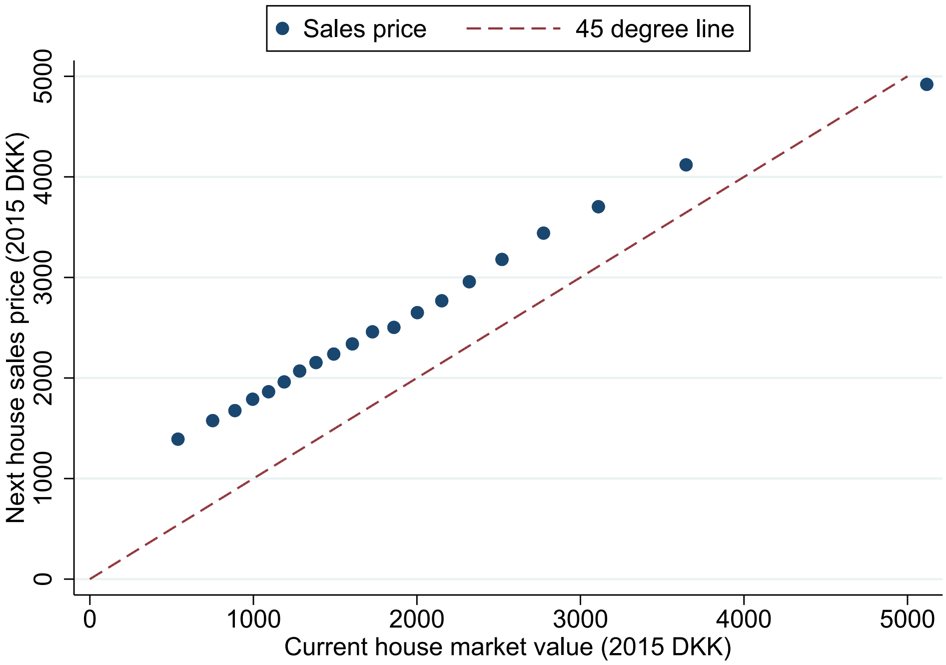


Figure A.32

Understanding the Extensive margin: Home Equity

This figure reports the share of listed houses relative to the stock of all houses, across 5% bins of home equity.

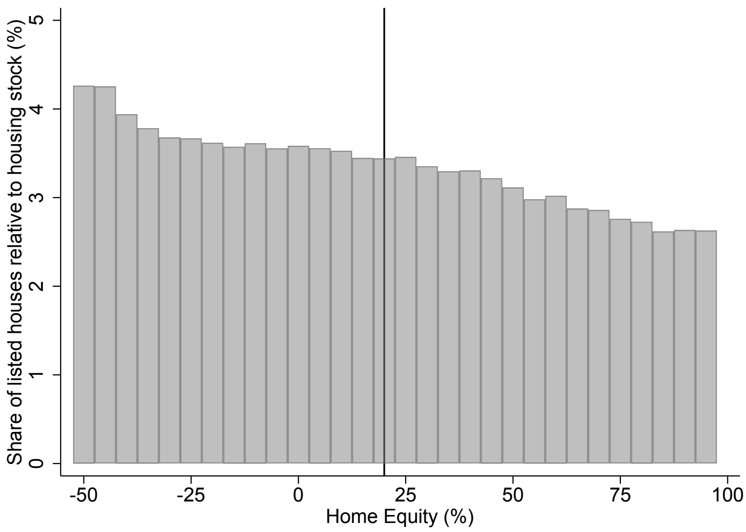


Figure A.33

Illustration of Homogeneity of Housing Stock for IV Estimation

Panel A illustrates what is defined as "row houses" in the Danish building and housing register (Bygnings- og Boligregistret). Each registered property can be looked up on the register via . The right-hand side shows a screenshot of the property outline of a house that is part of a row house unit. On contrast, Panel B shows the property outline of a detached single family house, which has visibly different features from other surrounding houses and is less homogeneous than the row house unit.

Panel A

Panel B

Figure A.34
Listing Premium-Gain Slope and Demand Concavity

This figure the listing premium over gains (left-hand side) and demand concavity (right-hand side) patterns when sorting municipalities by the estimated demand concavity, using municipalities in the top and bottom 5% of observations. Demand concavity is estimated as the slope coefficient of the effect of listing premium on probability of sale within six months, for $\ell \in [0, 50]$. The listing premium over gains slope is the slope coefficient of the effect of expected gains $\widehat{G}$ on listing premia, for $\widehat{G} < 0$.

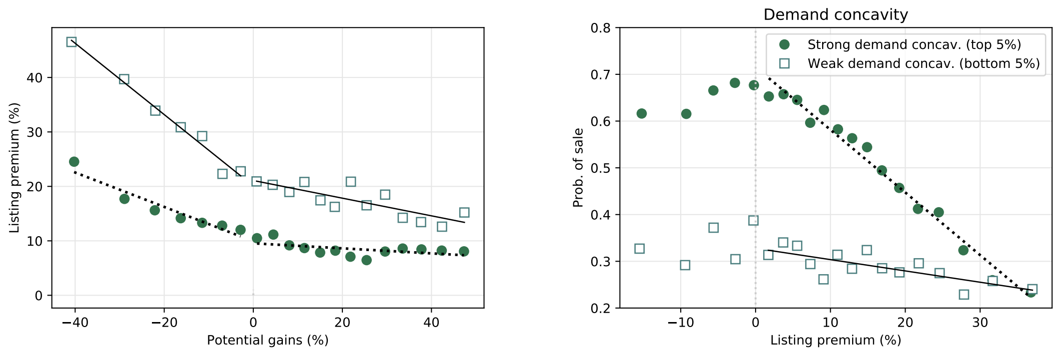


Figure A.35
Model fit

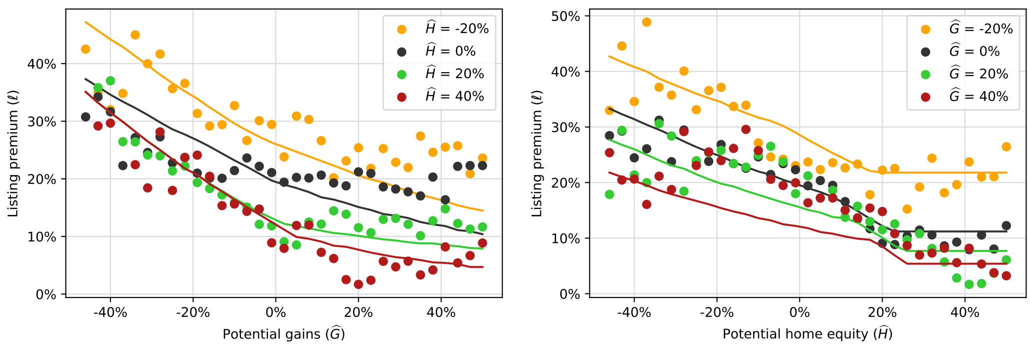


Figure A.36

Bunching around realized gains of zero (polynomial counterfactual)

The figure reports binned frequencies of observations (in 1 percentage point steps) for different levels of realized gains (G). The dotted line shows the counterfactual distribution using a 7th-order polynomial fit, with the excluded range of {-1%,1%}.

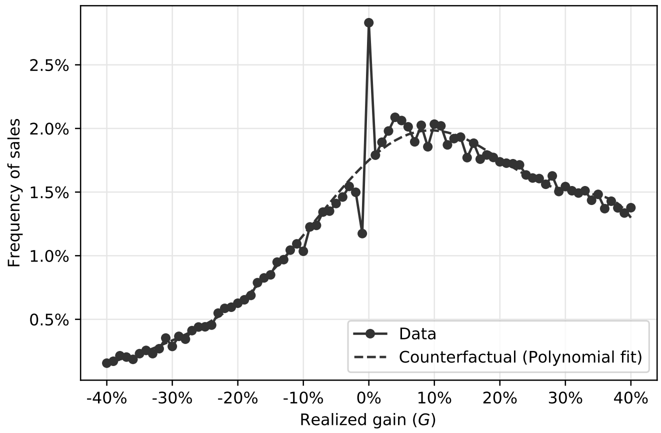


Figure A.37

Incidence of round numbers by rounding multiple

This figure shows the share of listed (sold) houses with a price at a given round number.

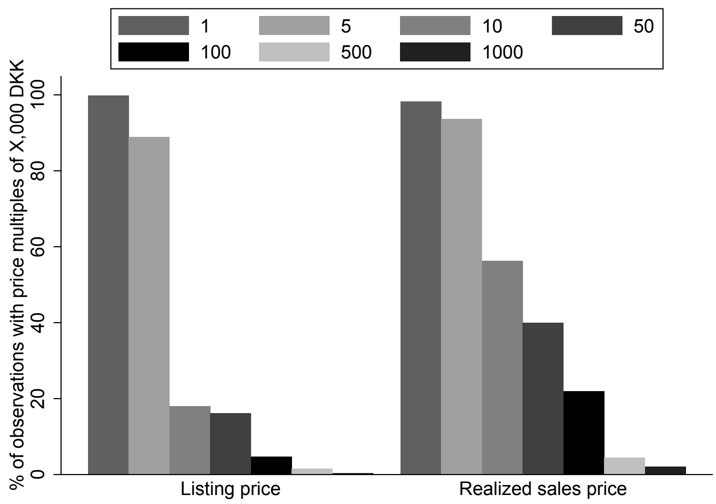


Figure A.38

Bunching robustness: excluding sales at rounded prices (10,000 and 50,000 DKK)

This figure shows robustness for the frequency of sales across realized gains (right-hand panel), against bunching being driven by round sales prices. The frequency is computed without sales that take place at 10,000 and 50,000 DKK, respectively. The blue dots represent the empirical frequency of observations in each 1 percentage point gain bin, and the red line reflects the fitted polynomial counterfactual model.

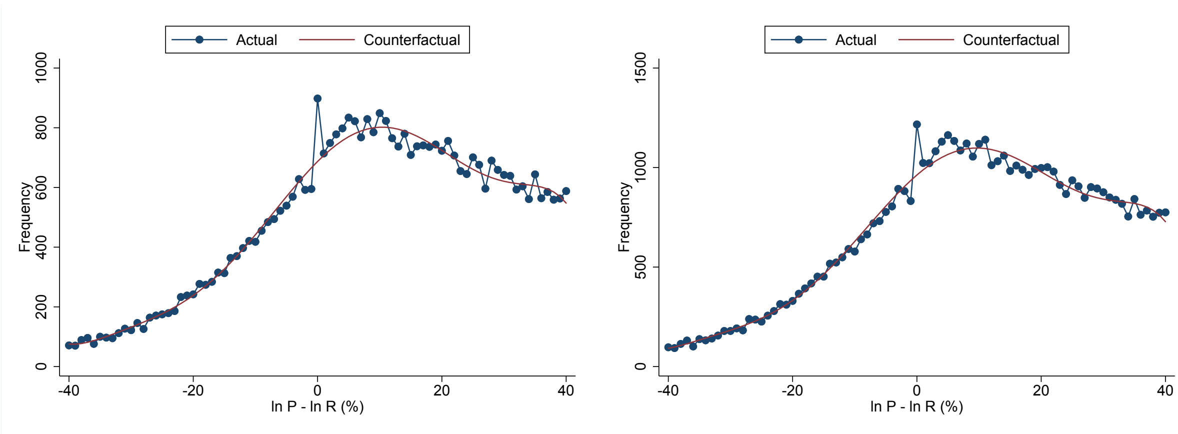


Figure A.39

Bunching robustness: excluding sales at rounded prices (100,000 and 500,000 DKK)

This figure shows robustness for the frequency of sales across realized gains (right-hand panel), against bunching being driven by round sales prices. The frequency is computed without sales that take place at 100,000 and 500,000 DKK, respectively. The blue dots represent the empirical frequency of observations in each 1 percentage point gain bin, and the red line reflects the fitted polynomial counterfactual model.

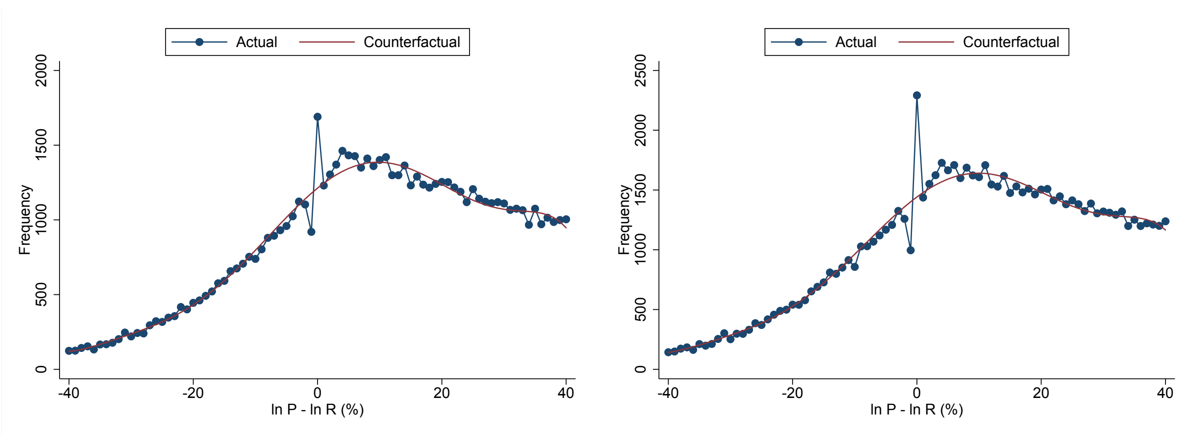


Figure A.40

Bunching robustness: previous sales price - gains at realized price

This figure shows robustness for the frequency of sales across gains at the realized price, by splitting the sample by quintiles of the previous sales price. The blue dots represent the empirical frequency of observations in each 1 percentage point gain bin, and the red line reflects the fitted polynomial counterfactual model.

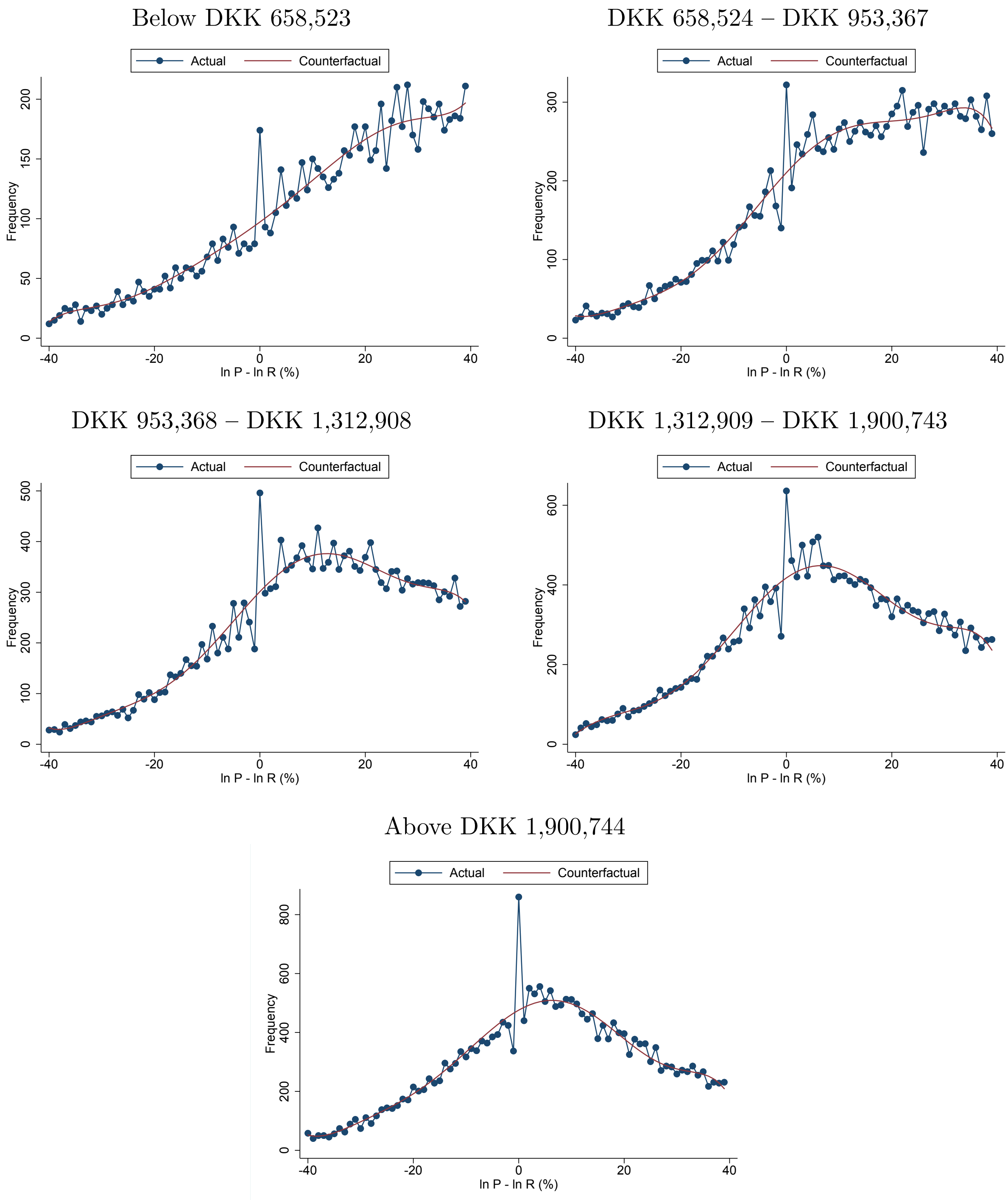


Figure A.41

Bunching robustness: holding period - gains at realized price

This figure shows robustness for the frequency of sales across gains at the realized price, by splitting the sample by quintiles of the months since last sale (holding period). The blue dots represent the empirical frequency of observations in each 1 percentage point gain bin, and the red line reflects the fitted polynomial counterfactual model.

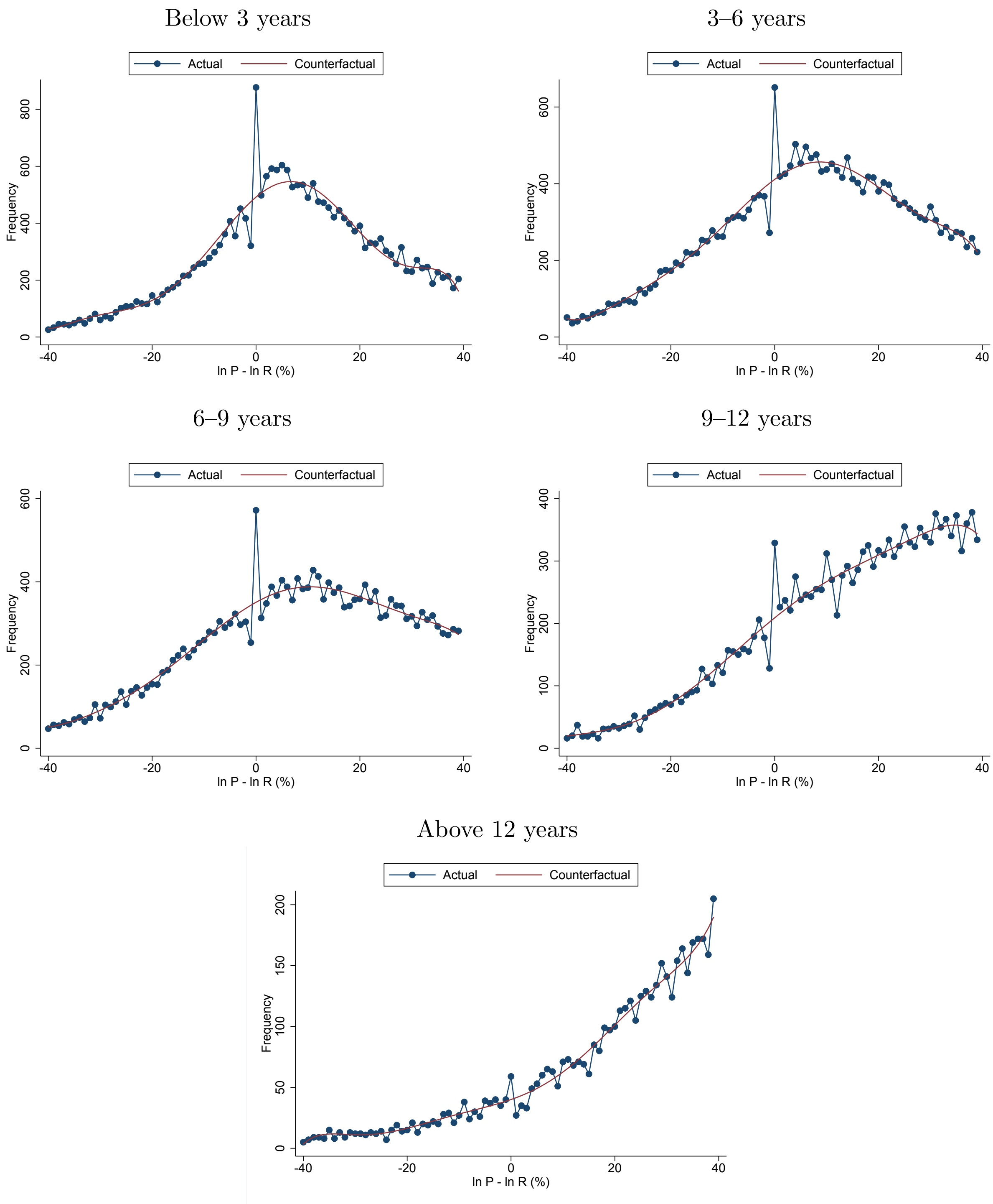
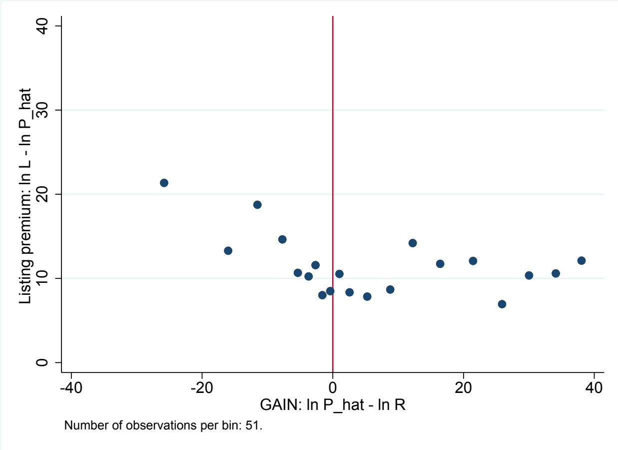


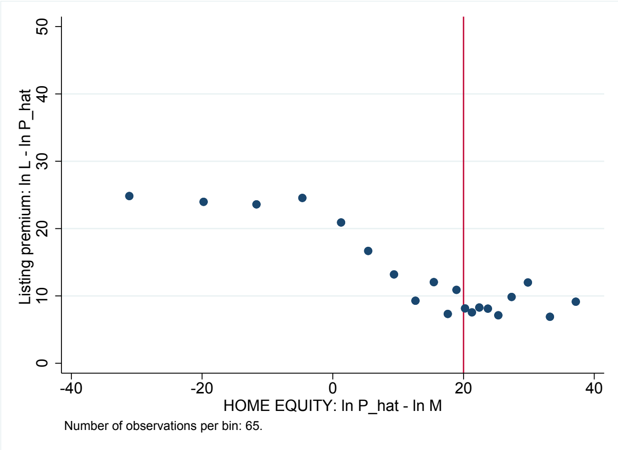
Figure A.42
Main relationships for matched sample

The sample consists of properties from our final sample matched to properties that have been excluded because they where last traded before 1992.

(a) Listing premium - gain



(b) Listing premium - home equity



(c) Demand concavity

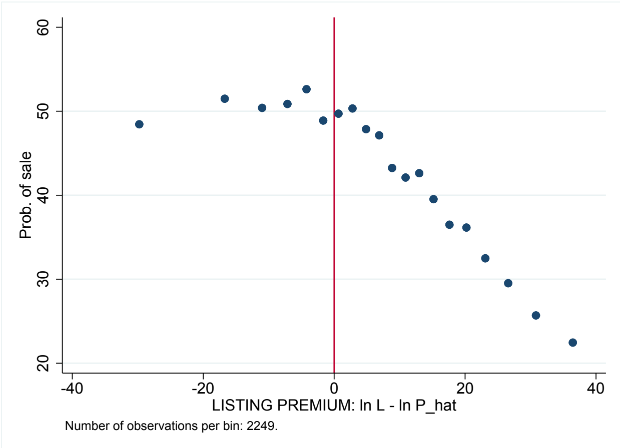


Figure A.43

Model sensitivity to parameters

This figure illustrates the mapping from moments to estimated parameters. In the spirit of Andrews et al. (2017), we vary each of the structural parameters and re-compute model-implied moments. Solid red lines indicate the level of the moment in the data. Dotted red lines show the 95% confidence interval in the data based on bootstrap standard errors. The horizontal solid lines show how sensitive the moments are to variation in each of the parameters.

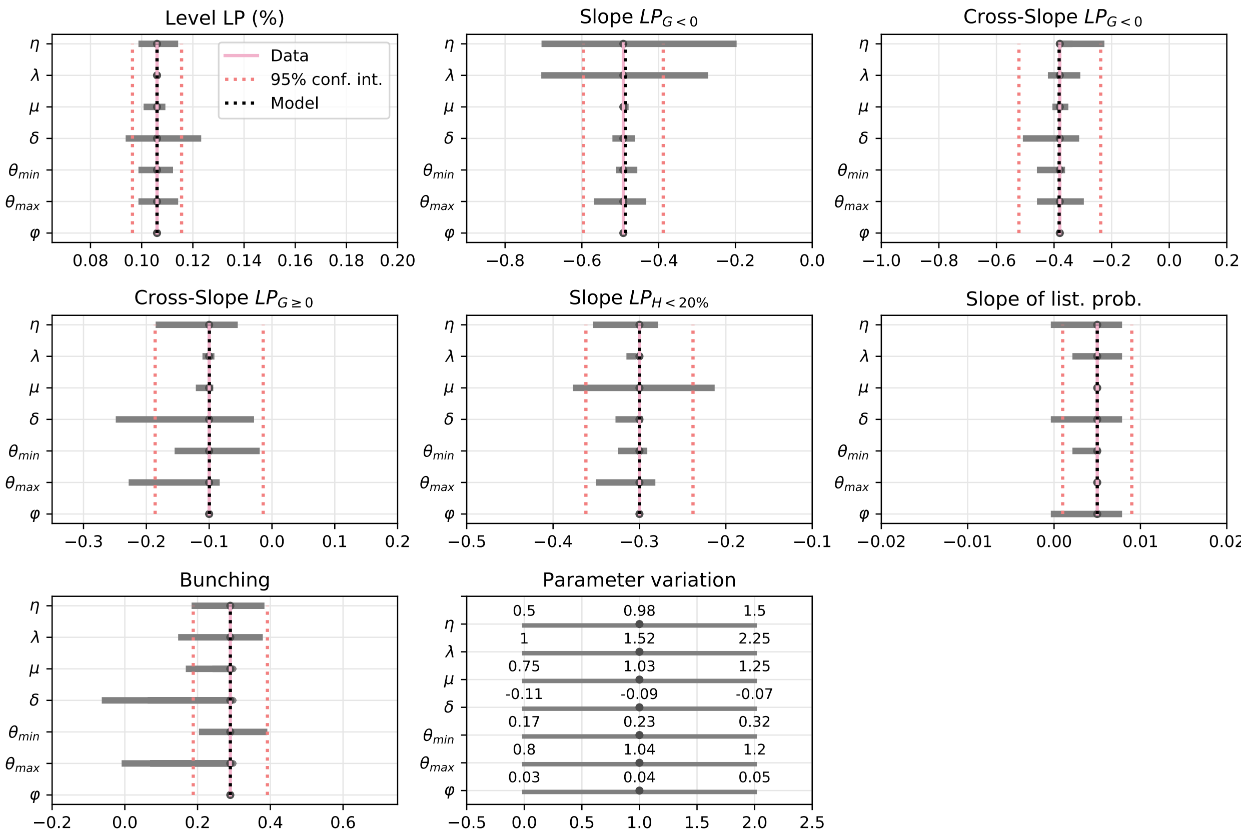


Figure A.44

Gains vs. home equity: Bunching

The figure reports binned average values (in 3% steps) for the observed excess bunching of sales along levels of realized gains and home equity. We calculate the measure of excess bunching as the difference between the frequency of sales in a given bin of *realized* gains and home equity, and the the frequency of sales in the same bin of *potential* gains and home equity. The dotted lines show the binned values for two cross-sections, where we condition on a home equity level of 20%, and a level of gains of 0%, respectively.

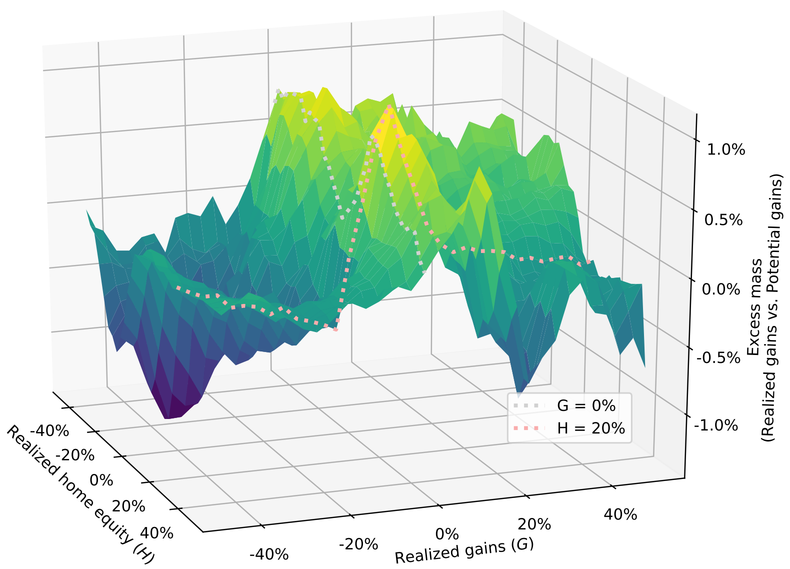


Table A.1
Construction of Main Dataset

This table describes the cleaning and sample selection process from the raw listings data to the final matched data.

All listings of owner-occupied housing[a]	**614,798**
Unmatched in registers[b]	-107,582
	507,216
Cleaning	
No reference price[e]	-144,974
Owner ID not uniquely determined[d]	-71,883
Non-household buyer	-10,175
Foreclosures	-6,310
Extreme price	-5,495
Owner ID not found[c]	-3,982
Missing lot size	-2,814
Error in listing or purchase date[f]	-1,925
Intra-family sale or other special circumstances	-1,733
No listing price	-882
Missing hedonic characteristics	-8
	257,035
Sample selection	
Summer house	-24,138
Professional investor[g]	-18,389
Final data	**214,508**
Of which with a mortgage	173,065
Of which without a mortgage	41,443

[a] *Excluding listings of cooperative housing. We identify cooperative housing using the ownership register, which between version 1 and 2 was updated for 2016 by Statistics Denmark*
[b] *Reasons could be misreported addresses or non-ordinary owner-occupied housing.*
[c] *No owner ID found in registers.*
[d] *E.g. properties with several owners from different households.*
[e] *Purchased before 1992.*
[f] *Listing date is before purchase date.*
[g] *Seller owns more than 3 properties.*

Table A.2
Observables by inclusion in sample

This table show means and standard deviations of properties in our final sample (Column 1), and the corresponding properties that have been sorted out because we do not know the purchase price (Column 2). In addition Column 3 shows characteristics of a matched sample of listed properties. Column 3 properties are sampled from Column 1 and matched to properties in Column 2 using exact matching on listing year, apartment, lot size decile, distance to city decile, and nearest neighbor matching on tax-assessed value. Matching is done with replacement. All properties fulfill all other restrictions, presented in Table A.1

	Sample	No found purchase price	Matched sample
	mean/sd	mean/sd	mean/sd
Apartment	0.29	0.11	0.11
	0.45	0.31	0.31
Lot Size	655.47	11984.37	1535.40
	1958.02	53599.92	5368.16
Interior Size	118.81	145.85	144.85
	45.93	50.24	51.80
Rooms	4.08	4.81	4.77
	1.52	1.54	1.54
Bathrooms	1.04	1.06	1.06
	0.22	0.26	0.26
Showers	1.01	1.03	1.02
	0.18	0.21	0.20
Unoccupied	0.06	0.09	0.06
	0.24	0.28	0.24
BuildingAge	63.54	57.55	63.08
	36.98	44.63	42.39
Historic	0.01	0.00	0.01
	0.09	0.07	0.08
Rural	0.11	0.26	0.22
	0.31	0.44	0.42
Distance to city (km)	36.41	43.42	43.32
	34.09	32.75	32.57
Tax assessment	1562.68	1887.73	1826.33
	990.17	1248.42	1057.24
Listing price	2131.28	2456.47	2450.25
	1473.34	1678.92	1599.68
Hedonic price	1896.51		2158.73
	1205.91		1248.11
Holding length	7.67		8.20
	5.07		5.35
Observations	173048	80842	80419

Table A.3

Overview of Alternative Models for $\widehat{P}$

This table provides an overview of the alternative models for $\widehat{P}$ and the number of observations used for model estimation as well as the resulting number of estimated prices in the final sample. R^2 is from the model estimation of logs.

	Main hedonic	Extended hedonic	Repeat sales	Repeat sales (sold more than twice)	Municipality Price Index	Shire Price Index (2)
			Final sample estimation (2009-2016)			
Timeinvariant property characteristics	✓	✓	✓	-		
Timevariant property characteristics	✓	✓		-		
Property - size interactions		✓		-		
Municipality - sales year fixed effects	✓	✓	✓	-	✓	
Municipality - purchase year fixed effects		✓		-		
Shire - sales year fixed effects				-		✓
Property fixed effects			✓	-		
Final sample size	214,494	214,405	26,680	-	42,155	39,796
Estimation sample	150,890	150,890	25,386	-	150,889	147,866
R^2	0.8769	0.8828	0.9743	-	0.3544	0.5139
			Full sample estimation (1992-2016)			
Timeinvariant property characteristics	✓	✓	✓	✓		
Timevariant property characteristics	✓	✓				
Property - size interactions		✓				
Municipality - sales year fixed effects	✓	✓	✓	✓	✓	
Municipality - purchase year fixed effects		✓				
Shire - sales year fixed effects				-		✓
Property fixed effects			✓	✓		
Final sample size	214,494	194,653	185,141	104,053	203,500	199,568
Estimation sample	1,683,001	884,256	1,176,459	661,213	1,797,081	1,795,264
R^2	0.8410	0.6388	0.9192	0.9025	0.4230	0.5341

Table A.4
Out-of-sample test of hedonic model

This table show mean R^2 from 1000 regressions of realized price on out-of-sample-predicted hedonic prices.

	(1)	
	Mean	
50 pct out-of-sample	0.875	(0.0000233)
25 pct out-of-sample	0.876	(0.0000402)
100 pct in-sample	0.878	(.)
Observations	1000	

Standard errors in parentheses

Table A.5
Out-of-sample test of hedonic model w/o tax-assessed value

This table show mean R^2 from 1000 regressions of realized price on out-of-sample-predicted hedonic prices.

	(1)	
	Mean	
50 pct out-of-sample	0.765	(0.0000378)
25 pct out-of-sample	0.766	(0.0000666)
100 pct in-sample	0.769	(.)
Observations	1000	

Standard errors in parentheses

Table A.6

Decomposition of the hedonic model: R^2

This table shows R^2 from different hedonic models: *YearMuni* models realized price using only municipality-year fixed effects. *Location* controls for rural area and distance to city. *Size* controls for interior size, lot size, number of bathrooms and showers. *HistUnoccu* constrols for historic buildings and unoccupied properties. *BuildingAge* for the age of the building. *TaxValue3rd* includes ln(TaxValue) as a third degree polynomial, just like it appears in the baseline hedonic model. *TaxValue* has only ln(TaxValue) in a linear form. Column 1 show a simple model using only the mentioned controls. Column 2 adds controls one by one.

	Simple	Accumulative
YearMuni	.477	.477
Location	.217	.512
Size	.263	.759
HistUnoccu	.041	.764
BuildingAge	.010	.768
TaxValue3rd	.800	.876
TaxValue	.792	.

Table A.7

Loss Aversion and Down-Payment Constraints: Baseline Results

This table reports results for four regressions. Column (4) represents the estimated coefficients from the saturated regression

$$\ell_{it} = \mu_t + \mu_m + \boldsymbol{\xi_0}\mathbf{X_{it}} + \alpha_1 \mathbb{1}_{G_{it}<0} + \alpha_2 \mathbb{1}_{\mathrm{H}_{it}<20\%} + (\beta_0 + \beta_1 \mathbb{1}_{G_{it}<0})G_{it} + (\gamma_0 + \gamma_1 \mathbb{1}_{\mathrm{H}_{it}<20\%})H_{it} + \epsilon_{it},$$

where ℓ_{it} is the listing premium, μ_t and μ_m are year and municipality fixed effects, respectively, and $\mathbb{1}_{G_{it}<0}$ and $\mathbb{1}_{\mathrm{H}_{it}<20\%}$ are indicator functions for households who face an expected gain or home equity lower than 20%, respectively. Column (1) and (2) report results for specifications with only gain or home equity coefficients separately, and column (3) corresponds to column (4) but excludes household controls (age, liquid financial wealth and bank debt). Standard errors are clustered by year and municipality. */**/*** denote $p < 0.10$, $p < 0.05$ and $p < 0.01$, respectively.

	(1) LP	(2) LP	(3) LP	(4) LP
α_1	0.795*		-0.181	-0.206
	(0.351)		(0.294)	(0.277)
β_0	-0.041***		-0.014***	-0.018***
	(0.004)		(0.004)	(0.004)
β_1	-0.473***		-0.368***	-0.362***
	(0.035)		(0.030)	(0.031)
α_2		8.679***	6.798***	6.686***
		(0.787)	(0.752)	(0.733)
γ_0		-0.082***	-0.071***	-0.074***
		(0.007)	(0.006)	(0.006)
γ_1		-0.104***	-0.084***	-0.081***
		(0.026)	(0.022)	(0.023)
Household controls				✓
Year FE	✓	✓	✓	✓
Observations	173873	173873	173873	173873
R^2	0.182	0.230	0.266	0.270

Table A.8

Replicating Main Results from Genesove and Mayer (2001)

This table replicates Table 2 from Genesove and Mayer (2001) using our main dataset. The dependent variable is the log ask price. LOSS is the previous log selling price less the expected log selling price, truncated from below at 0, and LOSS (squared) is the term squared. LTV if $\geq$ 80 is the current LTV of the property if the LTV is greater equal to 80 and 0 otherwise. Estimated hedonic house prices are assumed to be additive in baseline value and market index, where baseline value captures the value of hedonic characteristics of the property and the market index reflects time-series variation in aggregate house prices. Residual from last sales price is the pricing error from the previous sale and months since last sale counts the number of months between the previous and current sale.

	(1) Ask (log)	(2) Ask (log)	(3) Ask (log)	(4) Ask (log)	(5) Ask (log)	(6) Ask (log)
LOSS	0.538***	0.442***	0.520***	0.355***	0.557***	0.464***
	(0.016)	(0.016)	(0.026)	(0.026)	(0.016)	(0.016)
LOSS (squared)			0.050	0.238***		
			(0.056)	(0.056)		
LTV if $\geq$80	0.002***	0.002***	0.002***	0.002***	0.002***	0.002***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Baseline value	0.996***	0.993***	0.996***	0.993***	0.996***	0.994***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Market index at listing	0.993***	0.990***	0.993***	0.990***		
	(0.003)	(0.003)	(0.003)	(0.003)		
Residual from last sales price		-0.094***		-0.095***		-0.091***
		(0.003)		(0.003)		(0.003)
Months since last sale	-0.000**	-0.000***	-0.000**	-0.000***	0.000**	-0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Constant	0.390***	0.413***	0.391***	0.416***	76.059***	75.883***
	(0.025)	(0.026)	(0.025)	(0.026)	(0.211)	(0.211)
Year-Quarter FE					✓	✓
Observations	173065	157396	173065	157396	173065	157396
R^2	0.883	0.887	0.883	0.887	0.886	0.890

Table A.9
Listing price decomposition

This table shows the simple regression of log listing prices on hedonic price and previous purchase price.

	(1) $\ln L$
$\widehat{\ln P}$	0.897***
	(0.002)
$\ln R$	0.082***
	(0.002)
Observations	214508
R^2	0.87

Table A.10

Regression Kink Design

The table shows results from sharp RKD tests of loss aversion, using the 0% gain cutoff, and demand concavity, using the 0% listing premium cutoff, for varying bandwidths $b \in \{b^*, 15, 20\}$. b^* refers to the optimally chosen bandwidth using a MSE-optimal bandwidth selector from Calonico et al. (2014). The control variables are year fixed effects, household controls (age, education length and net financial wealth) and year of previous purchase. *, **, *** indicate statistical significance at the 10%, 5% and 1% confidence levels, respectively.

	(1) Gain	(2) Gain	(3) Gain	(4) P(sale)	(5) P(sale)	(6) P(sale)
RK estimate	0.364**	0.375**	0.277**	-0.558***	-0.611***	-0.662***
	(0.159)	(0.174)	(0.114)	(0.193)	(0.103)	(0.072)
Cutoff	0.00	0.00	0.00	0.00	0.00	0.00
Bandwidth	16	15	20	9	15	20
Polynomial order	2	2	2	1	1	1
N below cutoff	43068	43068	43068	42731	42731	42731
N above cutoff	130809	130809	130809	131146	131146	131146

Table A.11

IV Robustness: Shire Level

This table reports regression results for the relationship between the listing premium slope over gains and demand concavity. The dependent variable in all regressions is the slope of the listing premium over $\widehat{G} < 0$, across shires with at least 30 observations. Column 1 reports the baseline correlation with the demand concavity slope across municipalities using OLS. Column 2 reports the 2-stage least squares regression instrumenting demand concavity with the apartment-and row-house share. Column 3 reports the overidentified 2SLS regression with both instruments, row-house and apartment share and average distance to city. Panel B includes household controls (age, education length, net financial assets, and log income). Standard errors are clustered at the municipality-year level. *, **, *** indicate statistical significance at the 10%, 5% and 1% confidence levels, respectively.

Panel A

	(1) OLS	(2) 2SLS	(3) 2SLS (overid)
Demand concavity	-0.134***	-0.431***	-0.389***
	(0.027)	(0.122)	(0.114)
Observations	433	433	433
R^2	0.053		
First-stage F-stat	23.991	12.482	11.612
Hansen J-stat (p-val)			0.185

Panel B

	(1) OLS	(2) 2SLS	(3) 2SLS (overid)
Demand concavity	-0.087***	-0.431***	-0.427***
	(0.027)	(0.126)	(0.115)
Household controls	✓	✓	✓
Observations	433	433	433
R^2	0.167		
First-stage F-stat	17.082	13.271	13.767
Hansen J-stat (p-val)			0.936

Table A.12
IV Robustness: Logit Demand Concavity

This table reports regression results for the relationship between the listing premium slope over gains and demand concavity, using a logit specification for demand concavity. The dependent variable in all regressions is the slope of the listing premium over $\widehat{G} < 0$, across municipalities with at least at least 30 observations where $\widehat{G} < 0$ (Panel A), and shires with at least 30 observations, respectively (Panel B). Column 1 reports the baseline correlation with the demand concavity slope across municipalities using OLS. Column 2 reports the 2-stage least squares regression instrumenting demand concavity with the apartment-and row-house share. Column 3 reports the overidentified 2SLS regression with both instruments, row-house and apartment share and average distance to city. Panel B includes household controls (age, education length, net financial assets, and log income). Standard errors are clustered at the municipality-year level. *, **, *** indicate statistical significance at the 10%, 5% and 1% confidence levels, respectively.

Panel A

	(1) OLS	(2) 2SLS	(3) 2SLS (overid)
(mean) concav2	-0.223***	-0.333***	-0.338***
	(0.051)	(0.113)	(0.106)
Household controls	✓	✓	✓
Observations	95	95	95
R^2	0.637		
First-stage F-stat	31.268	27.615	27.787
Hansen J-stat (p-val)			0.895

Panel B

	(1) OLS	(2) 2SLS	(3) 2SLS (overid)
Demand concavity	-0.060***	-0.377***	-0.383***
	(0.023)	(0.114)	(0.108)
Household controls	✓	✓	✓
Observations	433	433	433
R^2	0.161		
First-stage F-stat	16.330	12.422	12.634
Hansen J-stat (p-val)			0.869

Table A.13

IV Robustness: Excluding Copenhagen and Aarhus

This table reports regression results for the relationship between the listing premium slope over gains and demand concavity, excluding the two largest cities in Denmark, Copenhagen and Aarhus. The dependent variable in all regressions is the slope of the listing premium over $\widehat{G} < 0$, across municipalities with at least at least 30 observations where $\widehat{G} < 0$ (Panel A), and shires with at least 30 observations, respectively (Panel B). Column 1 reports the baseline correlation with the demand concavity slope across municipalities using OLS. Column 2 reports the 2-stage least squares regression instrumenting demand concavity with the apartment- and row-house share. Column 3 reports the overidentified 2SLS regression with both instruments, row-house and apartment share and average distance to city. Panel B includes household controls (age, education length, net financial assets, and log income). Standard errors are clustered at the municipality-year level. *, **, *** indicate statistical significance at the 10%, 5% and 1% confidence levels, respectively.

Panel A

	(1) OLS	(2) 2SLS	(3) 2SLS (overid)
Demand concavity	-0.273***	-0.350***	-0.358***
	(0.059)	(0.115)	(0.108)
Household controls	✓	✓	✓
Observations	93	93	93
R^2	0.646		
First-stage F-stat	31.724	28.618	28.832
Hansen J-stat (p-val)			0.830

Panel B

	(1) OLS	(2) 2SLS	(3) 2SLS (overid)
Demand concavity	-0.069**	-0.379***	-0.403***
	(0.030)	(0.118)	(0.115)
Household controls	✓	✓	✓
Observations	364	364	364
R^2	0.182		
First-stage F-stat	15.948	13.444	13.428
Hansen J-stat (p-val)			0.497

Table A.14

Alternative Listing Premia: Premia to Average House Prices

This table reports regression results for the relationship of listing premia (ℓ), the premium to the average house price in a given market (Premium to Avg.), and the ℓ residual when partialling out the effect of Premium to Avg. Premium to Avg. is defined as the ask price less the market average mu_{it}. Column (1) to (4) report results when mu_{it} is defined over municipality-years (with similar results for municipality-year-quarter, not reported here), and column (5)-(8) report results when mu_{it} is defined over shire-years. Standard errors are clustered at the municipality-year level. *, **, *** indicate statistical significance at the 10%, 5% and 1% confidence levels, respectively.

	(1) P(sale)	(2) P(sale)	(3) P(sale)	(4) P(sale)	(5) P(sale)	(6) P(sale)	(7) P(sale)	(8) P(sale)
LP	-0.005***		-0.005***		-0.005***		-0.006***	
	(0.000)		(0.000)		(0.000)		(0.000)	
Premium to Avg		-0.001***	0.000***	-0.000		-0.001***	0.000***	0.000
		(0.000)	(0.000)	(0.000)		(0.000)	(0.000)	(0.000)
LP residual				-0.005***				-0.005***
				(0.000)				(0.000)
Observations	173004	173004	173004	173004	171724	171724	171724	171724
R^2	0.048	0.006	0.049	0.037	0.049	0.005	0.049	0.040

Table A.15

Estimated Parameters (Alternative Identification, No Concave Demand).

The table reports structural parameter estimates obtained through classical minimum distance estimation, in a model in which we assume linear demand $\alpha(\ell) = 0.6 - 0.53\ell$ estimated in the data. In this case we need to drop the moments implied by the cross-sectional variation of concave demand, and so we consider just a set of three moments (Level of ℓ for $\widehat{G} = 0\%$, Slope of ℓ-G for $\widehat{G} < 0\%$ and bunching above $G = 0\%$), and three parameters (η, λ and $\theta_{\max}$). All other parameters are as in the baseline specification. In parentheses, we report standard errors based on the estimated bootstrap variance-covariance matrix in the data, clustered at the shire level. *, **, *** indicate statistical significance at the 10%, 5% and 1% confidence levels, respectively.

η	=	0.750^{***}	(0.291)
λ	=	3.285^{***}	(0.867)
$\theta_{\max}$	=	4.535^{***}	(0.815)

Table A.16

Amendments to the Danish Mortgage-Credit Loans and Mortgage-Credit Bonds Act in the period from 2009 to 2016

May 2009	Allows a bankruptcy estate to make changes to fees in special circumstances
June 2010	Adjustments about bankruptcies
June 2010	Change of wording
December 2010	Change of wording
February 2012	Maximum maturity for loans to public housing, youth housing, and private housing cooperatives is extended from 35 to 40 years
December 2012	Elaboration of the rules on digital communication with the FSA
December 2012	Elaboration on the opportunity for mortgage credit institutions to take up loans to meet their obligation to provide supplementary collateral.
March 2014	Establish the terms under which the mortgage-credit institution can initiate sale of bonds if the term to maturity on a mortgage-credit loan is longer than the term to maturity on the underlying mortgage-credit bonds.
March 2014	Implements EU regulation. Change of wording on the definition of market value.
December 2014	Small additions to the terms under which the mortgage-credit institution can initiate sale of bonds if the term to maturity on a mortgage-credit loan is longer than the term to maturity on the underlying mortgage-credit bonds.
April 2015	Changes to the terms under which the mortgage-credit institution can initiate sale of bonds if the term to maturity on a mortgage-credit loan is longer than the term to maturity on the underlying mortgage-credit bonds.

Chapter 3

Who stops buying homes when prices fall?

Who stops buying homes when prices fall?[1]

Marcel Fischer[2] Natalia Khorunzhina[3] Julie Marx[4]

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[2]Marcel Fischer, Copenhagen Business School, Department of Finance, Solbjerg Plads 3, DK-2000 Frederiksberg, Denmark and University of Konstanz, Department of Economics, Postbox 147, D-78457 Konstanz, Germany, phone: +49 7531 882645, e-mail: marcel.fischer@uni.kn.

[3]Natalia Khorunzhina, Copenhagen Business School, Department of Economics, Porcelænshaven 16A, DK-2000 Frederiksberg, Denmark, phone: +45 3815 2403, e-mail: nk.eco@cbs.dk.

[4]Julie Marx, Copenhagen Business School, Department of Finance, Solbjerg Plads 3, DK-2000 Frederiksberg, Denmark, phone: +45 3815 3657, e-mail: jma.fi@cbs.dk.

Abstract

Who stops buying homes when prices fall?

We study the transition to and from homeownership under the recent housing market bust using detailed micro-level data covering the entire Danish population. We document that households that are more affected by falling house prices reduced their likelihood to acquire homeownership during the bust more than other households. These households are characterized by lower levels of net worth, lower income, shorter educations, are singles, and of younger age. Combined with younger households abandoning homeownership more under the bust, the bust contributed to a significant inter-generational shift in homeownership from younger to older households.

JEL Classification Codes: D12, D14, D91, E21, E32, G11, R21

Keywords: household finance, real estate finance, housing market bust, demand for homeownership

1 Introduction

The housing market boom and bust of the 2000's dramatically illustrates the need for a better understanding of how households decide on homeownership and whether differences in households' sociodemographic characteristics affect their homeownership decision over the housing market cycle. Case and Shiller (1989) document that returns on residential homes are highly positively autocorrelated. That is, lagged housing market returns partly predict present ones. In particular, house prices are more likely to decline if house prices in the previous period declined significantly. Such markets with rapicly falling home prices are typically accompanied by a lack of demand and a low trading volume, resulting in further rapid declines in house prices. We want to investigate whether certain groups of potential buyers reduce their propensity to acquire a home when prices fall more than others.

Intuitively, homeownership decisions should be more sensitive to past decreases in house prices than past increases. Increases in house prices primarily result in a positive wealth effect for homeowners. With falling house prices, however, there is a much higher degree of dispersion in how households are affected. Some households may be able to bear the negative wealth effect, others may run the risk of getting overindebted. In particular, younger households with low savings and income could face higher risks of getting overindebted. Hence, the propensity to become a homeowner in a market with falling prices should be lower for households that are more affected by falling house prices, i.e., younger households, households with low savings and income, households with low levels of education, and singles.

Our work tests these hypotheses using a large high-quality dataset covering all trades of owner-occupied homes in Denmark. Our main finding is that the propensity to acquire homeownership during the recent bust varied significantly with household characteristics. In particular, under the bust, younger households reduced their propensity to acquire homeownership more. Similarly, households with lower income, lower savings, short education, and singles reduced their propensity to become homeowners more. Other household characteristics vary less with the state of the housing market cycle and seem to play a less important role in explaining differences between the propensity to acquire homeownership under the bust and during other periods.

Macroeconomic factors such as interest rates (e.g., Landvoigt et al., 2015) as well as new types of mortgages and relaxed borrowing standards (e.g., Chambers et al., 2009; Amromin et al., 2018) have contributed to the recent housing market boom and bust. Less is known about the groups of households that were most affected by these macroeconomic changes. Notable exemptions are the works of Adelino et al. (2016) and Foote et al. (2016), which focus on investigating the distribution of mortgage debt among US households before and during the financial crisis.

When house prices have declined significantly, such as during the bust, homeownership should be an option for a larger number of households. However, the high degree of autocorrelation in residential house prices implies a second effect, namely negative expectations on house price changes in the near future. When house prices have been depreciating a lot, the high degree of autocorrelation in residential house prices suggests that a further decline in house prices is likely. In such a situation, it may be rational to defer the purchase of a home until house prices have bottomed out. Many countries, including the US, Great Britain, and China, experienced a massive decline in house rices. Denmark experienced a housing market boom and bust that is remarkably similar to its US counterpart. Using big data on all Danish households and all trades of homes of an entire nation, we investigate how the propensity to acquire homeownership varies over the housing market cycle with sociodemographic characteristics.

Complementing the work of Andersen et al. (2016) that focuses on homeowners and studies the correlation between consumption expenditure and leverage during the recent bust, we focus on households living in rented places and study how their propensity to acquire homeownership changes under the bust. Understanding who stops acquiring homeownership in busting markets is key to better understanding housing market busts for four reasons. First, Abel (2019) documents that the behavior of sellers can only explain a small proportion of the decline in aggregate sales, suggesting that busting housing markets are buyers' markets. Second, market entrants often buy smaller homes whereas the sellers of these homes mostly move to larger homes. That is, market entrants do not only affect the relatively cheap market segment they buy in, but also more expensive market segments (Ortalo-Magné and Rady, 1999, 2006). In our data, these spillover effects are reflected in a positive correlation between purchases of market entrants and repeated buyers.

Third, market entrants do not have to sell their current home before acquiring a new one. Fourth, in our robustness analysis, we document that the propensity to buy new homes by households that already live in owner-occupied places is driven by similar household characteristics as those of market entrants.

Our work contributes to a growing literature on the implications of housing market cycles and their causes. Departing from the pioneering work of Case and Shiller (1989), that was the first to document autocorrelation in residential house prices, one strand of this literature investigates the impact of these cycles on unemployment (Mian and Sufi, 2014) and entrepreneurship (Corradin and Poppov, 2015). Similarly, the dramatic consequences of the recent housing market bust for the values of mortgage-backed securities is well-documented. Yet, little is known about the extent to which sociodemographic characteristics alter the propensity to acquire a home during housing market busts.

Another strand of literature tries to rationalize autocorrelation in residential house prices via search frictions (Head et al., 2014), biased expectations of homebuyers (Glaeser and Nathanson, 2017), or pro-cyclical behavior of short-term buyers (DeFusco et al., 2020) and investigates the implications of the high degree of autocorrelation in residential house prices. Despite high transaction costs, it is rational to time market entries and exits (Fischer and Stamos, 2013; Corradin et al., 2014).

Empirically, in areas with high past house price appreciations, individuals buy at earlier ages than in areas with low past house price appreciations (Agarwal et al., 2016). We contribute to this line of literature by focusing on the bust period, during which heterogeneity among the propensity to acquire homeownership should be highest. Complementing the work of Agarwal et al. (2016) that focuses on trades during the boom, we find that younger households acquire homeownership significantly less frequently once house prices start tumbling. Similarly, younger households showed a higher likelihood to abandon homeownership than other households during such periods.

On the aggregate level, these differences lead to a remarkable intergenerational shift in homeownership. The homeownership rate of younger households, in which the oldest member is younger than 30 years, showed a remarkable drop from about 22% before house prices started falling to less than 18% in 2010. Similarly, the homeownership rates among households with the oldest member being 30 to 39 also decreased. During the same time, the homeownership rate among older households slightly increased, while the homeownership rate in the total population remained fairly stable at around 55%.

This paper proceeds as follows: Section 2 motivates why the impact of household characteristics on the decision to acquire a home should vary over the housing market cycle in a simple stylized two-date model. Section 3 presents our data and our empirical framework. In section 4, we discuss our main results, section 5 documents the robustness of our results to trades of current owners. Section 6 concludes.

2 A simple two-date model

To motivate our empirical analysis, we present a simple two-date model, in which rational households derive utility from consuming a non-durable good and living in an owner-occupied home. For the purpose of our motivating model, we abstract away from modeling borrowing constraints. Initially, at time $t = 0$, a households is endowed with net worth W_0 and decides how much to spent on non-durable consumption and whether to acquire a home. At time $t = 1$, the household derives utility form its remaining net worth, W_1, including the value of the home.[1]

With a time preference parameter of β, a household's expected lifetime utility can be written as

$$U_0 (C_0) + x\chi_H + \beta\mathbb{E} [U_1 (W_1)] , \quad (1)$$

in which U_0 is the household's utility function defined over non-durable consumption at time $t = 0$, U_1 is a strictly concave utility function over terminal net worth at time $t = 1$, x measures the utility gain from living in an owner-occupied home, and χ_H is an indicator variable that takes the value one if the household lives in an owner-occupied home, i.e., acquires a home at time

[1] In a two-period setting, the remaining net worth, W_1 is consumed. In a setting with more than two dates, the remaining wealth, W_1, could also be used to finance consumption at time $t = 1$ and reinvested for future periods. Irrespective of whether we focus on a model with two or more dates, a higher level of W_1 is associated with a higher level of lifetime utility. For the purpose of motivating our empirical approach, it is therefore sufficient to work in a two-date model.

$t = 0$, and zero otherwise. The price of the home is normalized to one. Denoting the household's labor income at time t by Y_t, the budget constraint can be written as

$$W_1 = (W_0 + Y_0 - C_0 - \chi_H) R + \chi_H R_H + Y_1, \tag{2}$$

in which R denotes the gross return on the household's financial investments, and R_H is the gross return on the owner-occupied home that consists of an expected constant drift, c_H, an expected cyclical drift, r_H, that depends on the state of the housing market cycle, and an error term, ϵ_H, that accounts for the unpredictable component in the evolution of residential house prices. That is,

$$R_H = 1 + c_H + r_H + \epsilon_H. \tag{3}$$

The household chooses current consumption, C_0, and homeownership status, χ_H, to maximize expected utility from Equation (1) subject to its budget equation (2).

We let C_0^N and W_1^N denote the household's levels of consumption and net worth, respectively, when the household does not invest in an owner-occupied home. C_0^H and W_1^H denote their counterparts when the household does invest in an owner-occupied home, respectively. It is then optimal to acquire a home if

$$U^H = U_0\left(C_0^H\right) + x + \beta\mathbb{E}\left[U_1\left(W_1^H\right)\right] > U^N = U_0\left(C_0^N\right) + \beta\mathbb{E}\left[U_1\left(W_1^N\right)\right]. \tag{4}$$

From Equation (2),

$$W_1^H = \left(W_0 + Y_0 - C_0^H\right) R + \chi_H \left(R_H - R\right) + Y_1. \tag{5}$$

Whether an investment into an owner-occupied home is desirable depends on whether $U^H > U^N$ or not. From Equations (4) and (5), this in turn depends on the cyclical housing premium r_H. With the envelope condition, it holds that

$$\frac{\partial\left(U^H - U^N\right)}{\partial r_H} = \beta\mathbb{E}\left[\frac{\partial U_1\left(W_1^H\right)}{\partial r_H}\right] = \beta\mathbb{E}\left[\frac{\partial U_1\left(W_1^H\right)}{\partial W_1^H}\right] > 0. \tag{6}$$

That is, low values of r_H, i.e., bad states of the housing market cycle, make an investment into an owner-occupied home less attractive.

We want to investigate whether households' sensitivity to changes in r_H is related to other sociodemographic characteristics, $X_{i,0}$, i.e., whether

$$\frac{\partial^2\left(U^H - U^N\right)}{\partial r_H \partial X_{i,0}} = \beta\mathbb{E}\left[\frac{\partial^2 U_1\left(W_1^H\right)}{\partial W_1^H \partial X_{i,0}}\right] = \beta\mathbb{E}\left[\frac{\partial U_1'\left(W_1^H\right)}{\partial W_1^H} \cdot \frac{dW_1^H}{dX_{i,0}}\right], \tag{7}$$

in which $U_1'\left(W_1^H\right) = \frac{\partial U_1\left(W_1^H\right)}{\partial W_1^H}$ is positive, negative, or zero for a given (continuous) characteristic $X_{i,0}$ at time $t = 0$. Assuming a concave utility function over wealth, marginal utility decreses with wealth and the first factor in Equation (7) is negative. Understanding how a characteristic affects the propensity to acquire homeownership is then largely associated with understanding how it affects the second factor, $\frac{dW_1^H}{dX_{i,0}}$.

We begin our analysis by asking whether the household's initial wealth level, W_0, affects the desirability of acquiring homeownership. It holds that

$$\frac{dW_1^H}{dW_0} = \frac{\partial W_1^H}{\partial W_0} + \frac{\partial W_1^H}{\partial C_0}\frac{\partial C_0}{\partial W_0} = \left(1 - \frac{\partial C_0}{\partial W_0}\right)R. \tag{8}$$

For reasonably-behaved utility functions, households aim at smoothing their consumption over the life cycle. In other words, households do not consume the entire increase in W_0 immediately, but save part of it for future consumption. That is, the term $1 - \frac{\partial C_0}{\partial W_0}$ should be positive. From the first factor in Equation (7), households with higher wealth levels have lower marginal utilities of wealth at time $t = 1$ and are therefore less sensitive to bad states of the housing market cycle. In other words, households with lower wealth levels should shy more away from acquiring homeownership in bad states of the housing market cycle.

From the work of Cocco et al. (2005), other household characteristics, such as age, education, or marital status, are important drivers of household income when regressing the log of household income on a set of household characteristics:

$$\ln(Y_t) = \sum_{i=1}^{n} \alpha_i X_{it} + v_t + \epsilon_t, \tag{9}$$

in which $v_t = v_{t-1} + u_t$ with normally distributed u_t with mean zero and variance σ_u^2 accounts for the persistence in labor income. We next turn to investigating how the level of the investor's permanent component, v_t of labor income affects the propensity to acquire homeownership in bad states of the housing market cycle. For that purpose, we ask how varying v_0 affects the demand for homeownership. It holds that

$$\begin{aligned}
\frac{dW_1^H}{dv_0} &= \frac{\partial W_1^H}{Y_0}\frac{\partial Y_0}{\partial v_0} + \frac{\partial W_1^H}{\partial C_0}\frac{\partial C_0}{\partial Y_0}\frac{\partial Y_0}{\partial v_0} + \frac{\partial W_1^H}{\partial Y_1}\frac{\partial Y_1}{\partial v_0} + \frac{\partial W_1^H}{\partial C_0}\frac{\partial C_0}{\partial Y_1}\frac{\partial Y_1}{\partial v_0} \\
&= RY_0 - RY_0\frac{\partial C_0}{\partial Y_0} + Y_1 - RY_1\frac{\partial C_0}{\partial Y_1} \\
&= RY_0\left(1 - \frac{\partial C_0}{\partial Y_0}\right) + Y_1\left(1 - R\frac{\partial C_0}{\partial Y_1}\right).
\end{aligned} \tag{10}$$

Due to the consumption-smoothing motive, $1 - \frac{\partial C_0}{\partial Y_0}$, is positive. Likewise, an increase in future labor income should again lead to a consumption-smoothing policy. That is, part of the future increase will be spend on future and part on present consumption. That is, $1 - R\frac{\partial C_0}{\partial Y_1}$ should be positive. Hence, an increase in permanent labor income increases future wealth and thus decreases its marginal utility. In other words, the marginal utility of future wealth should be less sensitive to the state of the housing market cycle for households with higher income, whereas households with lower income should shy more away from acquiring homeownership in bad states of the housing market cycle.

From the first term Equation in (9), in addition to v_t, other household characteristics affect the household's labor income stream. Via labor income, household characteristics thus affect household wealth W_1^H and thus, ultimately, the marginal utility of wealth in Equation (7). For a given characteristic $X_{i,0}$, it holds that

$$\begin{aligned}\frac{dW_1^H}{dX_{i,0}} &= \frac{\partial W_1^H}{\partial Y_0}\frac{\partial Y_0}{\partial X_{i,0}} + \frac{\partial W_1^H}{\partial C_0}\frac{\partial C_0}{\partial Y_0}\frac{\partial Y_0}{\partial X_{i,0}} + \frac{\partial W_1^H}{\partial Y_1}\frac{\partial Y_1}{\partial X_{i,0}} + \frac{\partial W_1^H}{\partial C_0}\frac{\partial C_0}{\partial Y_1}\frac{\partial Y_1}{\partial X_{i,0}} \\ &= RY_0\alpha_i - R\frac{\partial C_0}{\partial Y_0}Y_0\alpha_i + Y_1\alpha_i\frac{\partial X_{i,1}}{\partial X_{i,0}} - R\frac{\partial C_0}{\partial Y_1}Y_1\alpha_i\frac{\partial X_{i,1}}{\partial X_{i,0}} \\ &= RY_0\alpha_i\left(1 - \frac{\partial C_0}{\partial Y_0}\right) + Y_1\alpha_i\frac{\partial X_{i,1}}{\partial X_{i,0}}\left(1 - R\frac{\partial C_0}{\partial Y_1}\right).\end{aligned} \tag{11}$$

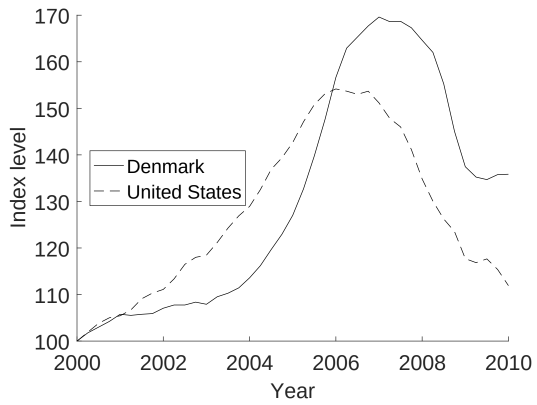
From above, both $1 - \frac{\partial C_0}{\partial Y_0}$ and $1 - R\frac{\partial C_0}{\partial Y_1}$ should be positive. Whether the entire expression in Equation (11) is positive or negative then depends on the signs of α_i and $\frac{\partial X_{i,1}}{\partial X_{i,0}}$.

If $X_{i,t}$ measures the length of an individual's education, then $\frac{\partial X_{i,1}}{\partial X_{i,0}}$ is either one (if the individual is finished with its longest education at time $t = 0$) or positive (if the individual is still in progress with the education). Income generally increases in the level of an individual's education, i.e., the α_i-coefficient for education should be positive. Higher income in turn leads to higher future wealth. Hence, our theoretical model predicts that the marginal utility of wealth at time $t = 1$ is lower for individuals with a longer education. That is, individuals with a shorter education should shy more away from acquiring homeownership in bad states of the housing market cycle.

From Table 1 in Love (2010) and Table 1 in Fischer and Khorunzhina (2019), married individuals have a higher level of household income and a lower volatility of their income. More technically, this empirical observation translates into the α_i from being married exceeding its counterpart for being single in Equation (11). With both the level of household income being higher and the volatility being lower for married individuals, the (average) marginal utility of wealth is lower for married than for singles. Hence, singles that do not change their marital status should shy more away from acquiring homeownership in bad states of the housing market cycle than married households that do not change their marital status.

From Figure 1 in Cocco et al. (2005), household income generally increases with the age of the head of household – particularly prior to age 40. If $X_{i,t}$ is the individual's age, then $\frac{\partial X_{i,1}}{\partial X_{i,0}} = 1$ and $\alpha_i > 0$ at younger age. That is, since younger households' labor income is typically lower than older households', younger households should shy more away from acquiring homeownership in

Figure 1
Evolution of house prices over time



This figure depicts the evolution of house prices in Denmark (solid line, data from the OECD) and the United States (dashed line, Case Shiller house price index) from 2000 to 2010. The indices are normalized to 100 in the first quarter of 2000.

bad states of the housing market cycle than older households.

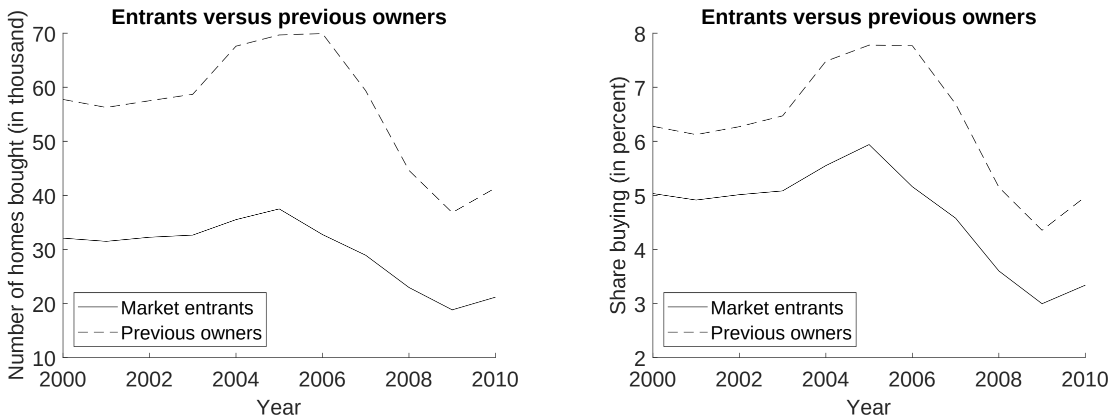
In total, from our theoretical model, we conjecture that households with lower income, households with lower net worth, shorter education, singles, and younger households are less likely to acquire homeownership in bad states of the housing market cycle than other households.

3 Data

Our analysis is conducted with Danish Registry Data (DRD) that is mostly third-party reported and covers the entire Danish population of about 5.5 million inhabitants. As we outline in more detail in Section 3.4, having data for the entire population alleviates many concerns about attrition and selection.

Similar to the United States and several other countries, Denmark experienced a sharp increase in residential house prices followed by a rapid decline between 2000 and 2010. From Figure 1, the evolution of house prices in Denmark is similar to its US counterpart. Yet, rapid increases and declines in house prices seem even more pronounced. From Figure 2 and in line with the prediction from the model of Stein (1995), the sharp decline of house prices is closely related to a sharp decline in the number of households acquiring homeownership. Using data covering

Figure 2
Market entrants versus previous owners



This figure depicts the evolution of the absolute number of homes bought (left panel) and the share of individuals acquiring a home (right panel) between 2000 and 2010. The solid lines show results for market entrants; the dashed lines for previous owners.

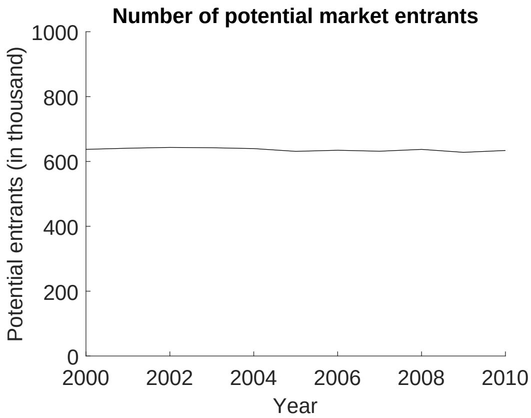
the entire population of Denmark, i.e., all Danish households, we investigate which groups of households altered their propensity to acquire homeownership most and are therefore likely to have played an important role in the housing market bust.

Even if changes in the propensity to acquire homeownership may appear rational, we do not claim these changes to be solely driven by changes in household preferences. A decrease in the propensity to acquire homeownership may also reflect external constraints – in particular generally tightening credit conditions under the bust. That is, changes in the propensity to acquire homeownership may not only reflect the households' unwillingness to overtake the increased housing market risk, but also the banks'.

We focus on market entrants, i.e., households that change their homeownership status from renter to owner, for two reasons.[2] First, market entrants' timing of acquisitions of homes are subject to less frictions. Conditional on getting a loan, the timing of the acquisition of market entrants should therefore better reflect their true preferences. Second, market entrants do not only affect the market via their own trade, but – via spillover effects – also other market segments (e.g., Ortalo-Magné and Rady, 1999, 2006). We therefore focus our investigation on the propensity to acquire homeownership of potential market entrants, i.e., households that have been renters for at

[2]We deliberately only consider households as market entrants if they have been living in a rented place for at least a full year to avoid capturing cases that only temporarily live in a rented place, because they managed to sell their old home, but have not yet finalized the purchase of a new one.

Figure 3
Potential market entrants



This figure depicts the number of potential market entrants between 2000 and 2010.

least two consecutive years and ask how sociodemographic characteristics change their propensity to become homeowners with the stage of the housing market cycle. From Figure 2, the number of homes bought by previous homeowners is closely related to that of market entrants. The same is true for the share of previous homeowners acquiring homeownership.[3]

From Figure 3, the number of potential market entrants is remarkably stable over time, indicating that the impact of potential market entrants on house prices should not primarily be driven by a change in their number, but instead by changes in their propensity to acquire a home. For all those reasons, we focus our empirical analysis on the behavior of market entrants throughout. In robustness checks in section 5.1, we document that current owners' propensities to acquire a new home are related to sociodemographic characteristics in a qualitatively similar fashion as those of potential market entrants.

Similar to the United States, where living in an owner-occupied home is part of the American Dream, a strong preference for living in an owner-occupied home is also deeply rooted in the Danish society. Danish households rarely abandon homeownership unless adverse events, such as financial problems, a divorce, or physical conditions at old age, force them to do so.[4] Simultane-

[3]In section 5.1, we document that the characteristics driving purchases of homes during bust periods of market entrants and current owners are remarkably similar.

[4]The share of households in which the oldest member is not exceeding the age of 60 that abandon homeownership is only at around 1% to 1.5% per year in our data.

ously, markets with falling house prices are typically buyers-markets in which a large number of homes on the market meets a small number of potential buyers. For all those reasons, we mainly focus on households' propensities to acquire owner-occupied homes in our empirical analysis. In section 5.2, we also explore the propensity to abandon homeownership.

Property transaction records in our data contain information about all home sales and purchases in Denmark from 1993 through 2010 linked to detailed background information on the individuals involved in a trade. We define a household as acquiring a home, the moment the purchase agreement is signed. To account for a few cases in which, despite a signed agreement, a households did not gain ownership, we additionally require households to own the home in the following or (to account for delayed legal transfers) next-following year to classify the signed contract as a trade.

From various registers we get basic demographics such as age, gender, education, number of children, and employment status for each individual living in Denmark. We then use the unique household ID to make households our unit of investigation. We use the beginning-of-year observations at time $t + 1$ to define the "acting households" that jointly make housing decisions. For households in our sample we collect information about household income, savings, and debt, which is normalized to 2015 Danish Kroner using the Danish Consumer Price Index (1 US-dollar corresponds to about 6 to 7 Danish Kroner).

The DRD has, among others, been used in previous work to investigate whether household consumption expenditure is correlated with changes in house prices (e.g., Browning et al., 2013), to explore how households decide about mortgage refinancing (e.g., Andersen et al., 2020), and to study the impact of forced sales on house prices (e.g., Andersen and Nielsen, 2017).

3.1 Data selection and cleaning

We restrict our data to the calendar years 2004 to 2010 for two reasons. First, the housing market boom and bust was most pronounced in these years. Second, similar to the United States, where the share of interest-only (IO) mortgages was less than 2% until 2003, but 30% two years later (Amromin et al., 2018), a reform allowed IO mortgages from 2004 onwards in Denmark. This reform is generally believed to have significantly altered the Danish housing market. To avoid a structural break in our data, we therefore focus on the years from 2004 onwards.

We define the years 2008 and 2009, in which real house prices fell by more than 6% each as the bust years.[5] In our base case setting, we focus on market entrants and remove households that live in an owner-occupied home at the beginning of the current or the previous period.[6] We also remove observations of households that live in cooperative housing at the beginning of the current or the previous year.[7] We focus on households in their prime earnings years, i.e., between ages 22 and 60. We exclude households younger than 22, because these households often have not yet finished their education.[8] Households beyond the age of 60 are excluded, because beyond the age of 60, households rarely enter the housing market. We exclude households with very unstable or unpredictable labor income, i.e., households that only consist of students, and households in which all adults receive public welfare benefits (Danish kontanthjælp). We further exclude households with at least one self-employed adult. Next, we exclude outliers, namely the top and bottom 0.5% of household net worth. We define net worth as the sum of net wealth in bank accounts, the market value of equity, bonds and t-bills plus the value of a possibly existing owner-occupied home minus the sum of all household debt. Pension savings are neither available in our data, nor can these savings under Danish law be liquidated prior to retirement age without paying tremendous penalty taxes. We therefore do not include them in our definition of household net worth.

Some sample cleaning is related to home trades. We remove trades between family members, because these trades are likely to be heavily affected by favorable tax treatment. We further remove

[5]We also considered a setting with local busts, in which we define a trade as occurring in a bust market if real house prices fell by more than 6% in the home's municipality. Our key findings reported throughout are largely structurally robust to this change in the definition of a bust.

[6]We investigate the behavior of current owners in section 5.1.

[7]In addition to living in an owner-occupied or a rented home, the Danish housing market offers a third type of homeownership status that is primarily found in larger cities: cooperative housing. In cooperative housing, a larger number of individuals jointly owns one or more building blocks through a cooperation. Each individual that is a member of the cooperation owns a share that simultaneously entitles it to live in a specific entity of the cooperation and makes it one of the owners of the cooperation. Despite legal constraints on the prices, at which these shares may be traded, some trade at prices close to the values of comparable owner-occupied places. Cooperative housing is thus in some regards similar to living in an owner-occupied home and more similar to living in a rented place in other regards. We do not investigate purchases of shares in cooperative housing, because they only account for a small share of the housing market and, because these trades are not registered in court, this data is not publicly available.

[8]We also considered a setting, in which we only removed households younger than 18 years. Our results are robust to this change and are therefore not reported here.

trades of households that acquire more than two homes in a single year and trades that Statistics Denmark marks as having a price clause or an extreme price.

Our final cleaned data set then consists of 4,435,979 household observations for the years 2004 to 2010.

3.2 Control variables

Homeownership is empirically significantly less widespread among singles than among couples. We therefore control for whether a household has a single female/male head or two adults. An important question in this regard is whether causality goes from becoming a couple to homeownership or vice versa. Fisher and Gervais (2011) document that becoming a couple drives homeownership, but not the other way around. Hence, it is important to control for the number of heads of household and changes in it. Given that cohabitation without marriage is very common in Denmark and cohabiting partners are treated similarly to married couples in many regards under Danish law, we deal with cohabiting adults like married ones.

We use a dummy for whether the adult household members have children.[9] We use dummies for whether the household member with the longest education has no highschool degree, a highschool education, or a college degree.[10] Other control variables in our regression framework are the age of the oldest household member, the log of household income, a dummy for whether household income per adult increased by more than 10% over the past year, year-fixed-effects, and municipality-fixed-effects. We also include a dummy for whether at least one family member has owned a property between 1993, the earliest observation that we have information about homeownership for, and the period under consideration. Lastly, we control for the number of years that

[9]In the data, there is a significant difference between the market entry behavior of households with and without children. However, conditional on having children, the exact number does not play a major role. We further investigated whether the age of the youngest child plays a role in explaining the propensity to acquire homeownership. While households with the youngest child not exceeding the age of 5 are more likely to acquire homeownership than households, in which the youngest child is older, the quantitative effect, e.g., as measured via the marginal effects, is small.

[10]More technically, we define the household member with the longest education as having no highschool degree, if his or her education does not extend beyond the ten years of schooling that are mandatory in Denmark. The household member with the longest education is classified as having a high school degree if it graduated from a highschool, a technical highschool or passed a (Danish) applied academy education, which is more applied than a highschool education, but typically takes a similar number of years to complete. If the household member with the longest education has a bachelor's degree or higher, we classify it as having a college degree.

no member of the household was a potential market entrant, i.e., a renter. When all members of the household were potential market entrants since 1993, we assume that they have been potential market entrants since the age of 22. Intuitively, if potential market entrants have been renters until at least 2003, i.e., for at least 10 years, they typically have a good reason for being renters and are therefore likely to also have been renters before.[11]

Information about house prices is easy to obtain in the Danish housing market; actual trading prices are published online. To control for the price expectations implied by autocorrelation in residential house prices, we include the lagged local house price growth in the housing market. Given the documented importance of past local house price changes (e.g., Guerrieri et al., 2013; Agarwal et al., 2016; Le Blanc et al., 2019), we compute the house price growth for each of the 98 Danish municipalities separately using a transaction-based hedonic price index.

3.3 Summary Statistics

In this section, we discuss key properties of our data in more detail. We begin by providing summary statistics in Table 1. Table 1 reports means and standard deviations (in parentheses) for potential market entrants (Panel A) and actual market entrants (Panel B). *Acquiring* denotes the share of potential market entrants that acquire homeownership, *Age* is the age of the oldest member in the household, *Net worth* is the total amount of household net worth. *Income* is total household income. *Single female (male)* is a dummy for whether the household has a single female (male) adult as head. *Children* is an indicator for whether children below the age of 18 are living in a household. *No highschool*, *Highschool*, and *College* are dummies for whether the household member with the longest education has no highschool degree, a highschool degree, or a college degree, respectively. *Experience* is a dummy indicating whether one of the adult household members has owned a home in the past. *Rental span* is the length of the current period of being a renter. *Lag ΔHPI* is the lagged real annual growth rate of house prices in the household's municipality.

[11] Our results are robust to measuring the number of years a household is living in a rented place assuming households were not living in a rented place prior to 1993 or truncating the number of years living in a rented place at 11, the maximum number of historical years for our earliest in-sample observation.

From Panel A of Table 1, the share of potential market entrants buying an owner-occupied home is only 3.3% in the bust years versus 4.9% in the other years. That is, in the bust years, potential market entrants' likelihood of acquiring homeownership decreases by 1.6 percentage points or more than 30 percent. We want to understand whether households with certain sociodemographic characteristics reduced their propensity to acquire homeownership more than others. From Panel B, market entries during the bust are more likely in states with less extreme past local price movements. The average lagged local house price growth of actual entrants in bust-years is only -0.1% compared to -1.9% for potential entrants in bust-years, indicating that during the bust, more trades occur in municipalities, where house prices fall less.

It is worth noting that potential market entrants in Denmark typically have negative levels of household net worth – and the same even applies for actual entrants. In Denmark, it is quite common to take out consumption loans to finance durable consumption, such as cars or furniture, but also non-durable consumption, such as holiday travels. In addition, household debt is subsidized in the sense that all household interest expenses – not only mortgage interest expenses – are tax-deductible. It is thus not surprising that Danish household debt is among the highest in Europe (OECD, 2020).

For Danish banks, pre-existing household debt is generally not an obstacle for providing households with a mortgage as well as a secondary loan, provided household income is sufficiently high to convince the bank that the household is able to serve the debt. Under Danish law, mortgage lenders have full recourse to all assets of a defaulting borrower. That is, unlike in some states in the United States, under Danish law, it is not possible to solely default on a mortgage.

In the Danish mortgage system, homeowners can take out a mortgage not exceeding 80% of the home's value. In addition, Danish households acquiring homeownership often take out a secondary loan, that comes as a bank loan, to debt-finance an even higher share of the home's purchase price. Danish real estate agents even commonly advertise with the amount in cash that potential new homeowners have to come up with on their own to make a typical bank willing to grant a mortgage as well as a secondary loan. This amount is typically 5% of the home's value. Households with negative levels of net worth are typically endowed with some form of household

Table 1
Summary statistics

	Panel A: Potential entrants			Panel B: Actual entrants		
Variable	All years	Bust-years	Other years	All years	Bust-years	Other years
Acquiring	0.045	0.033	0.049	1	1	1
	(0.206)	(0.179)	(0.216)	(0)	(0)	(0)
Age	38.385	38.443	38.361	34.462	35.007	34.315
	(11.262)	(11.282)	(11.255)	(9.262)	(9.495)	(9.193)
Net worth	-41,244	-45,239	-39,650	-28,163	-3,159	-34,864
	(317,737)	(328,502)	(313,323)	(522,716)	(579,258)	(506,283)
Income	223,401	227,643	221,708	282,010	292,210	279,276
	(112,447)	(117,666)	(110,250)	(128,770)	(151,923)	(121,674)
Single female	0.350	0.353	0.349	0.238	0.243	0.237
	(0.477)	(0.478)	(0.477)	(0.426)	(0.429)	(0.425)
Single male	0.349	0.358	0.345	0.183	0.184	0.183
	(0.477)	(0.479)	(0.476)	(0.387)	(0.387)	(0.386)
Children	0.261	0.257	0.263	0.349	0.355	0.348
	(0.439)	(0.437)	(0.440)	(0.477)	(0.479)	(0.476)
No highschool	0.293	0.292	0.294	0.119	0.121	0.119
	(0.455)	(0.455)	(0.455)	(0.324)	(0.326)	(0.323)
Highschool	0.433	0.420	0.438	0.537	0.520	0.541
	(0.495)	(0.494)	(0.496)	(0.499)	(0.500)	(0.498)
College	0.144	0.144	0.145	0.293	0.296	0.292
	(0.352)	(0.351)	(0.352)	(0.455)	(0.457)	(0.455)
Rental span	9.068	9.634	8.842	7.684	8.116	7.568
	(4.944)	(5.445)	(4.711)	(4.497)	(5.081)	(4.319)
Experience	0.173	0.179	0.170	0.273	0.293	0.268
	(0.378)	(0.384)	(0.375)	(0.446)	(0.455)	(0.443)
Lag ΔHPI	0.040	-0.019	0.063	0.050	-0.001	0.064
	(0.102)	(0.071)	(0.103)	(0.090)	(0.072)	(0.089)
N	4,435,979	1,265,307	3,170,672	197,551	41,755	155,796

This table reports means and standard deviations (in parentheses) for our potential market entrants (Panel A) and actual market entrants (Panel B). *Acquiring* denotes the share of potential market entrants that acquire homeownership, *Age* is the age of the oldest member in the household, *Net worth* is the total amount of the households' net worth. *Income* is total household income. *Single female (male)* is a dummy for whether the household has a single female (male) adult as head. *Children* is an indicator for whether children below the age of 18 are living in a household. *No highschool*, *Highschool*, and *College* are dummies for whether the household member with the longest education has no highschool degree, a highschool degree, or a college degree, respectively. *Rental span* is the length of the current period of being a renter. *Experience* is a dummy indicating whether one of the adult household members has owned a home in the past. *Lag ΔHPI* is the lagged real annual growth rate of house prices in the household's municipality.

debt and a certain level of liquid savings, implying that these households are often able to finance the required minimum downpayment and can acquire homeownership if granted a loan.

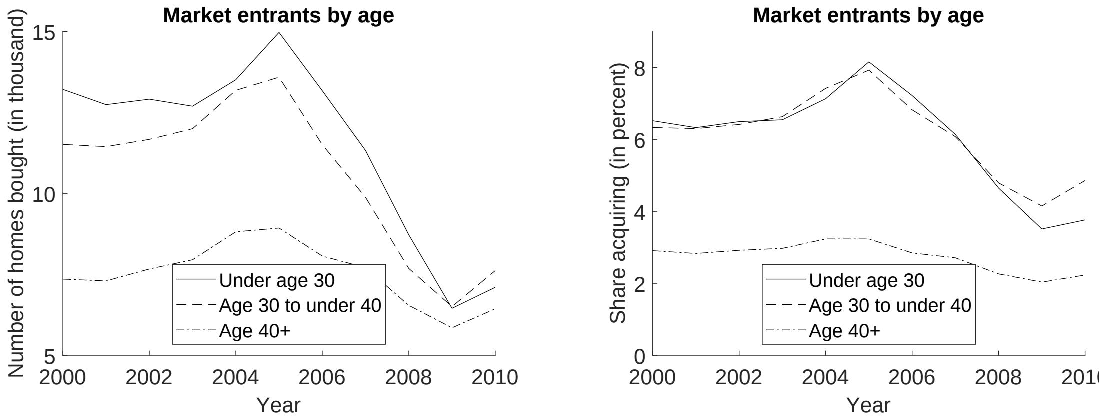
Similar to other countries, Danish banks tightened the requirements for granting loans under the housing market bust. It is therefore important to, among others, control for the differential impact of household net worth on the potential to acquire homeownership during the bust and other periods. Simultaneously, even if changes in households' propensities to acquire homeownership may appear as perfectly rational and may reflect the households' unwillingness to overtake huge homeownership risks in busting markets, the changes in the propensity to acquire homeownership may also partly reflect banks' unwillingness to overtake these risks by granting (secondary) loans.

Despite the huge difference in the likelihood of acquiring homeownership, from Table 1, Panel A and similar to the key finding of Gabriel and Rosenthal (2015), potential market entrants do not differ much in terms of characteristics in bust and other years. In those two periods, they are similar in terms of age, have similar levels of net worth, and income, and have about the same number of children.

Changes in the composition in the group of market entrants are therefore unlikely to offer an explanation for the huge changes in the likelihood of acquiring homeownership. Instead, these households with largely unaltered characteristics seem to have changed their propensity to acquire homeownership. From Table 1, Panel B, during bust periods, actual market entrants differ especially along three characteristics compared to other stages of the housing market cycle. First, during bust periods, market entrants are on average almost a year older. Second, during bust periods, actual market entrants are on average endowed with higher levels of net worth. Third, during bust periods, actual market entrants are endowed with higher income levels. Other household characteristics of market entrants are very similar in bust and other periods and thus unlikely to help understand the dramatic decrease in market entries during the bust period.

From our simple two-date model in section 2, we expect the impact of age, net worth, income, education, and marital status on the propensity to acquire homeownership to vary over the housing market cycle. We first turn to illustrating the impact of age on the number of market entries as well as the propensity to acquire homeownership graphically. Figure 4 depicts the number (left

Figure 4
Market entrants by age



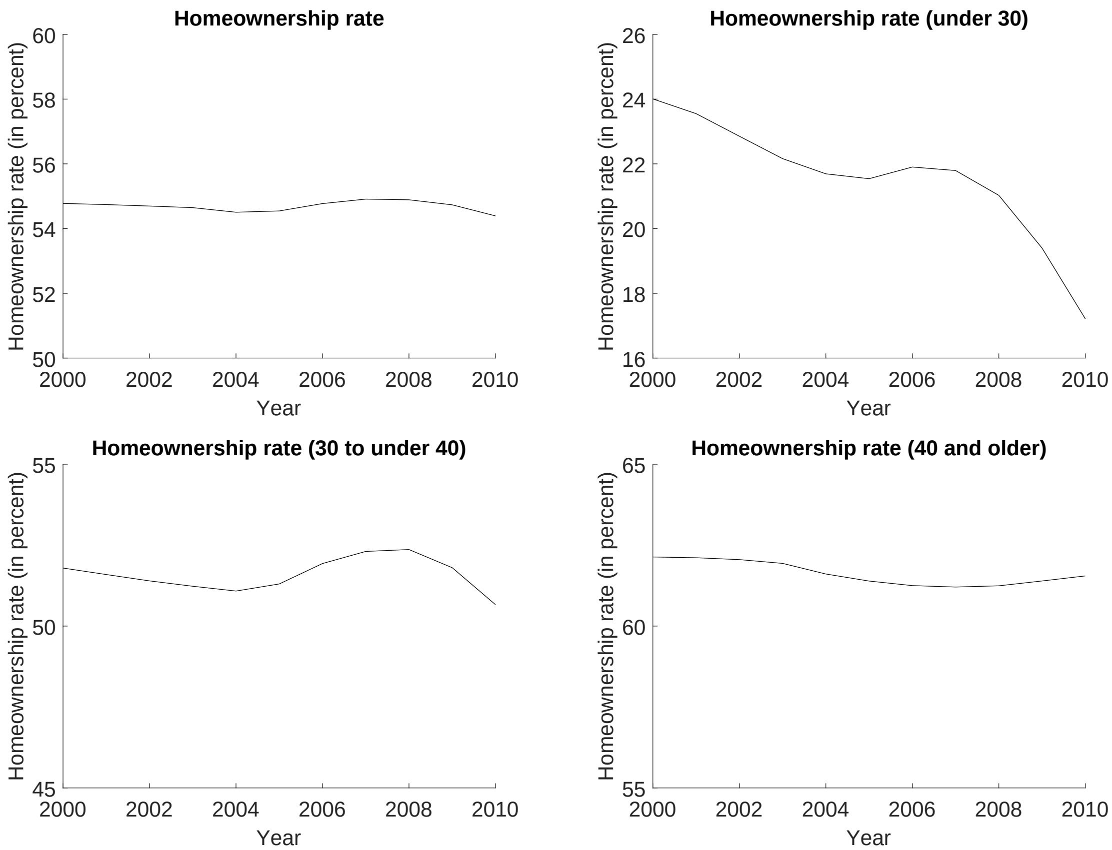
This figure depicts the absolute number (left panel) and share of potential market entrants (right panel) acquiring homeownership by age of the oldest member of the household. The solid lines show results for households in which the oldest member is younger than 30, the dashed lines results in which it is 30 to under 40, and the dash-dotted lines results when it is at least 40.

panel) and the share of potential market entrants (right panel) that acquire homeownership by the age of the oldest member of the household. Both the absolute number of market entries as well as the shares of individuals acquiring homeownership is highest for households where the oldest member is younger than 40 years, reflecting the high social value of living in an owner-occupied home in Denmark. Given the spillover effects from the market segment they trade in to other market segments, these young households presumably play a key role in generating liquidity in the market for owner-occupied homes. Consistent with our model's predictions from section 2, Figure 4 shows that under the recent housing market bust this group of households reduced its market entries more than older households – both in absolute and in relative terms.[12] As a matter of fact, already before the bust, households reduce their propensity to acquire homeownership, and younger households reduce their propensity more. Within the group of households above the age of 40, the share of households acquiring a home is fairly homogeneous and does not vary much with age.

The change in younger households' propensity to acquire homeownership has had important implications for homeownership among different age groups. Whereas the upper left panel in Figure 5 shows that the homeownership rate in the population remained fairly stable at around 55%,

[12]Further supporting our model's predictions, we also find households with low income or net worth to shy more away from entering the housing market under the bust than other households.

Figure 5
Homeownership rate



This figure depicts the evolution of the homeownership rate on household level for the total population of at least age 22 in the upper left panel as well as for households in which the oldest family member is younger than 30 years (upper right panel), 30 to less than 40 years (lower left panel) or at least 40 years (lower right panel) between 2000 and 2010.

the upper right panel shows that the change of younger households' propensity to acquire homeownership has led to a significant change in the homeownership rate among different age groups. In particular, during the bust and the preceding years, homeownership rates among households in which the oldest member was younger than 30 dropped significantly, whereas changes for other age groups were more modest. The only age group for which homeownership rates increased during the bust are older households. Complementing the work of Gabriel and Rosenthal (2015) that investigates the determinants of changes in the aggregate homeownership rate under the recent boom and bust in the US, our work documents huge inter-generational shifts in homeownership, particularly a massive decline in younger households' homeownership rates.

3.4 Empirical framework

We assume that the propensity to become a homeowner, y^*_{ikt}, is related to a vector of exogenous socioeconomic and demographic variables as well as a stochastic error term:

$$y^*_{ikt} = \theta_1 X_{it} + \theta_2 X_{it} BUST_t + \theta_3 Z_{kt} + \eta_t + \lambda_k + \varepsilon_{ikt} \tag{12}$$

$$y_{ikt} = \begin{cases} 1, & \text{if } y^*_{ikt} > 0 \\ 0, & \text{otherwise,} \end{cases}$$

in which i indexes individual, k indexes municipality, t indexes year, and $BUST_t$ is an indicator for whether the housing market was in a bust period in year t ($BUST_t = 1$) or not ($BUST_t = 0$). Market entries occur when y^*_{ikt} exceeds a critical value (normalized to 0). The model includes household characteristics, X_{it}, such as age, income, net worth, education, or family composition. X_{it} also includes a one to account for state-dependent constants. Given the importance of the evolution of the local housing market, we also include the lagged municipality-specific housing market return, Z_{kt}. To account for time-varying differences in the macroeconomic environment, such as the general level of the interest rate or the tightening loan conditions under the bust, we include year-fixed effects, η_t. We further include municipality-fixed effects, λ_k, to account for local factors, such as differences in unemployment rates, through municipalities. We assume that the random error term, ε_{ikt}, has a normal distribution.

We let P_{it} denote the probability that the household i becomes a homeowner in period t. The probability of first-time homeownership is then characterized by $P_{it} = P(y^*_{ikt} > 0)$. We estimate Equation (12), using a Probit model and data on the binary outcome of the decision to acquire homeownership to access the statistical significance of our regressors. Our model's predictions can then be interpreted as the probability of a household i with given control variables, such as given age, income, local house price growth, etc., acquiring a home at time t.

Given that our administrative data covers the entire population, in our data, attrition should – unlike in survey data – not be a major concern. Many potential market entrants in year t do not acquire a home and are therefore still potential market entrants in year $t + 1$. To account for this overlap on the econometric level in our Probit model, we build on the work of Beck et al. (1998) and control for the length of the most recent span of being a renter.

A direct assessment of the economic significance is not straightforward, since in the non-linear Probit model the effect of any regressor on the decision to acquire a home depends on the numerical values the other regressors take. To nevertheless investigate the economic significance of our regressors, we ask how a change in a given regressor affects the probability of entering the housing market. Using the estimated model, we compute average marginal effects for the covariates included in our model. These marginal effects use the actual observed values for the variables whose values are not exogenously fixed. The marginal effects of categorical variables are calculated using discrete first-differences. Similarly, again using the actual observed values for the variables whose values are not fixed exogenously, we compute model-implied probabilities of buying in bust states and other states of the housing market cycle.

4 Empirical Results

In the previous sections, we illustrated that potential market entrants dramatically reduced their likelihood of acquiring homeownership. Simultaneously, the number of potential market entrants as well as their characteristics remained stable over time, indicating that changes in the composition of this group of households are unlikely to explain the massive decline in market entries under the housing market bust. Instead, we want to document in this section that these households changed their propensity to acquire homes.

Households with certain characteristics may have had stronger incentives to postpone the acquisition of a home or to completely abandon an acquisition. Likewise, it may have been more difficult for households with certain characteristics to get a loan during the housing market bust. From our theoretical model in section 2, younger households as well as households with lower income or net worth should reduce their propensity to acquire homeownership more than others. In this section, we run regressions and compute (average) marginal effects to investigate whether these predictions are backed up by the data after controlling for other household characteristics as well as other exogenous factors introduced in section 3.4.

Table 2 depicts results from a Probit regression of the likelihood of a potential market entrant acquiring homeownership as a function of household characteristics and other exogenous controls. All variables are defined in the caption of Table 2. Standard errors are clustered on the household level.[13]

From Table 2, household characteristics, such as age, income, net worth, education, or marital status have a statistically significant impact on the likelihood to enter the housing market. In particular, from a comparison of the three columns, these effects are robust to adding municiaplity- and year-fixed effects. A direct assessment of the economic effects based on the regression coefficients from Table 2 is difficult due to the non-linearity of the Probit model as well as the possibility of correlation between the bust-dummy and other variables, the bust-dummy is interacted with. To assess the economic importance of our explanatory variables, we therefore report average marginal effects of our explanatory variables in Table 3. These effects can be directly interpreted as the average change in the probability to enter the housing market in response to a change in the corresponding explanatory variable by one unit.

From Table 3, household characteristics do not only have a statistically, but also economically significant impact on the propensity to acquire homeownership. For instance, after controlling for other characteristics, the propensity to acquire homeownership decreases on average with about

[13] According to Wooldride (2010), clustering on household level accounts for potential intertemporal correlations among the decisions to acquire homeownership for a panel of our length.

Table 2
Regression results for potential market entrants

Regressor	(1)	(2)	(3)
Age	-0.0141***	-0.0161***	-0.0162***
	(-62.84)	(-69.91)	(-70.02)
Age, bust	0.00295***	0.00340***	0.00354***
	(6.61)	(7.45)	(7.76)
Second net worth decile	-0.233***	-0.276***	-0.283***
	(-49.11)	(-56.81)	(-58.18)
Second net worth decile, bust	-0.160***	-0.150***	-0.137***
	(-15.84)	(-14.67)	(-13.51)
Fifth net worth decile	-0.231***	-0.238***	-0.239***
	(-43.54)	(-44.22)	(-44.34)
Fifth net worth decile, bust	-0.00939	-0.00578	-0.00318
	(-0.81)	(-0.46)	(-0.19)
Tenth net worth decile	0.361***	0.395***	0.386***
	(17.40)	(18.84)	(18.34)
Tenth net worth decile, bust	0.0639	0.0613	0.0627
	(1.41)	(1.34)	(1.37)
Logincome	0.0840***	0.0779***	0.0785***
	(30.05)	(28.59)	(28.02)
Logincome, bust	-0.00981	-0.00928	-0.00895
	(-1.87)	(-1.86)	(-1.77)
Single male	-0.645***	-0.666***	-0.667***
	(-163.14)	(-165.04)	(-164.94)
Single male, bust	0.0132	0.00595	0.00864
	(1.60)	(0.71)	(1.03)
Single female	-0.673***	-0.679***	-0.679***
	(-184.10)	(-181.24)	(-180.95)
Single female, bust	0.0266***	0.0169*	0.0181*
	(3.55)	(2.22)	(2.38)
Children	0.0223***	0.00126	0.000883
	(7.03)	(0.39)	(0.27)
Children, bust	0.0290***	0.0302***	0.0311***
	(4.52)	(4.64)	(4.78)
No highschool	-0.311***	-0.374***	-0.376***
	(-82.32)	(-96.24)	(-96.51)
No highschool, bust	0.00598	0.0183*	0.0246**
	(0.76)	(2.29)	(3.08)
College	0.221***	0.302***	0.308***
	(65.66)	(86.69)	(88.46)
College, bust	0.000566	-0.0195**	-0.0324***
	(0.08)	(-2.79)	(-4.63)
Rental span	-0.00804***	-0.00731***	-0.00716***
	(-32.05)	(-28.46)	(-27.87)
Rental span, bust	-0.000541	-0.00103*	-0.00114*
	(-1.08)	(-2.02)	(-2.24)
Bust	-0.0421	-0.0480	-0.188**
	(-0.66)	(-0.79)	(-3.04)
Other controls	YES	YES	YES
Municipality-fixed-effects	NO	YES	YES
Year-fixed-effects	NO	NO	YES
Observations	4,435,979	4,435,979	4,435,979

This table depicts results from Probit regressions of the likelihood of a potential market entrant acquiring homeownership. *Age* is the age of the oldest member in the household. *Second/fifth/tenth net worth decile* is an indicator for whether the households' net worth is in the second/fifth/tenth decile of the net worth distribution in the total population; dummies for all other net worth deciles are also included in our regressions. *Single female (male)* is an indicator for whether the household only has one female (male) adult household member. *Children* is an indicator for whether children below the age of 18 are living in the household. *No highschool* is an indicator for whether the household member with the longest education has no highschool education. *College* is an indicator for whether the household member with the longest education has a bachelor's degree. *Rental span* is the length of the current period of being a renter. Right handside variables interacted with an indicator for bust-years are marked with the word bust. *Other controls* are the other net worth deciles, a missing education dummy, a missing rental span dummy, an indicator for whether a household was newly formed, an indicator for whether a household was newly formed interacted with whether the household is two-headed, an indicator for whether at least one family member has owned an owner-occupied home in the past, and an indicator for whether household income grew by more than 10% in the previous period. The constant is not reported for brevity. t-statistics are reported in parentheses. *, **, and *** denotes significance at the 5%, 1% and 0.1% level, respectively. Standard errors are clustered on the household level.

Table 3
Average marginal effects for potential market entrants

Regressor	(1)	(2)	(3)
Age	-0.00111***	-0.00123***	-0.00123***
	(-68.31)	(-75.85)	(-76.09)
Second net worth decile	-0.0252***	-0.0284***	-0.0287***
	(-59.58)	(-66.42)	(-67.33)
Fifth net worth decile	-0.0223***	-0.0230***	-0.0230***
	(-48.89)	(-49.50)	(-49.57)
Tenth net worth decile	0.0542***	0.0597***	0.0580***
	(15.65)	(16.75)	(16.47)
Logincome	0.00671***	0.00607***	0.00611***
	(34.36)	(32.84)	(32.35)
Single male	-0.0613***	-0.0618***	-0.0615***
	(-181.90)	(-184.82)	(-185.55)
Single female	-0.0626***	-0.0623***	-0.0620***
	(-195.39)	(-194.66)	(-195.43)
Children	0.00239***	0.000650**	0.000637**
	(10.25)	(2.84)	(2.80)
No highschool	-0.0222***	-0.0249***	-0.0248***
	(-102.22)	(-119.87)	(-120.10)
College	0.0235***	0.0325***	0.0327***
	(68.99)	(87.01)	(88.23)
Rental span	-0.000670***	-0.000604***	-0.000592***
	(-36.90)	(-33.28)	(-32.81)
Bust	-0.00290***	-0.0105***	-0.0185***
	(-9.15)	(-42.58)	(-40.21)
Other controls	YES	YES	YES
Municipality-fixed-effects	NO	YES	YES
Year-fixed-effects	NO	NO	YES
Observations	4,435,979	4,435,979	4,435,979

This table depicts average marginal effects for the likelihood of a potential market entrant acquiring homeownership. *Age* is the age of the oldest member in the household. *Second/fifth/tenth net worth decile* is an indicator for whether the households' net worth is in the second/fifth/tenth decile of the net worth distribution in the total population; dummies for all other net worth deciles are also included in our regressions. *Single female (male)* is an indicator for whether the household only has one female (male) adult household member. *Children* is an indicator for whether children below the age of 18 are living in the household. *No highschool* is an indicator for whether the household member with the longest education has no highschool education. *College* is an indicator for whether the household member with the longest education has a bachelor's degree. *Rental span* is the length of the current period of being a renter. *Other controls* are the remaining net worth deciles, a missing education dummy, an indicator for whether a household was newly formed, the indicator for whether a household was newly formed interacted with whether the household is two-headed, an indicator for whether at least one family member has owned an owner-occupied home in the past, and an indicator for whether household income grew by more than 10% in the previous period. The constant is not reported for brevity. t-statistics are reported in parentheses. *, **, and *** denotes significance at the 5%, 1% and 0.1% level, respectively. Standard errors are clustered on the household level.

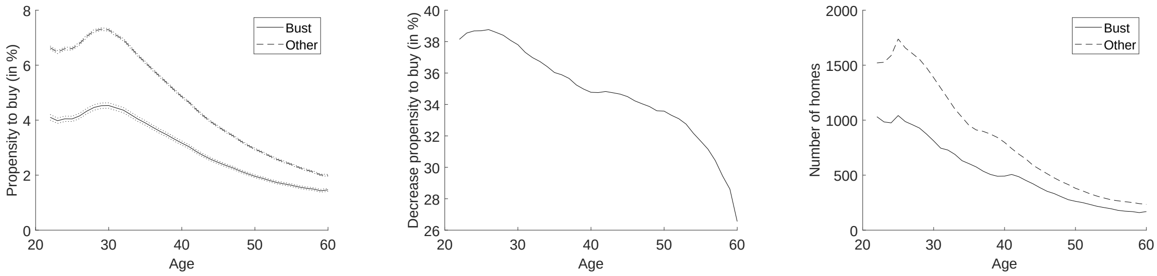
0.16 percentage points for every year an individual ages. Similarly, singles are about six to seven percentage points less likely to acquire homeownership than couples.

Whereas the results in Table 3 stress the general importance of household characteristics for potential market entrants' propensity to become homeowners, they do not allow for a direct assessment of the question which households changed their propensity to acquire homeownership most under the housing market bust. In contrast to our regression results from Table 2, Table 3 does not report results on interactions between the bust-dummy and other regressors, reflecting that a change in such an interacted term would simultaneously require a change in either the bust-dummy or the corresponding other regressor.

To investigate how the bust affected potential market entrants' propensity to become homeowners, we therefore next ask how potential market entrants' propensity to acquire homeownership varies with sociodemographic characteristics during the bust and other states of the housing market cycle and what the implications for the trading volume measured by the implied number of homes purchased by market entrants are. We begin this investigation in Figure 6, in which we depict the model-implied probability to acquire a home (Propensity to buy (in %)) by age in the left graph. The middle graph depicts the relative decrease in this propensity under the bust, i.e., the decrease of the predicted propensity to acquire homeownership under the bust compared to other stages of the housing market cycle in percent. The right graphs shows the predicted number of homes traded (Number of homes), computed as the product of the number of potential market entrants and the probability to acquire. All margins reported throughout are based on our full model specification (3).

In line with the predictions from our model in section 2 and the suggestive evidence in the raw data from Figure 4, Figure 6 illustrates that also after controlling for all other characteristics, younger households shied more away from becoming homeowners under the bust than other households. Changes in the predicted propensity to acquire homeownership are higher for younger households. Households below the age of 30 reduced their propensity to acquire homeownership by about 2.5 to 2.8 percentage points, corresponding to a decrease by more than 37 percent. Older households beyond the age of 50, on the other hand, only reduced their propensity to acquire

Figure 6
Market entries by age

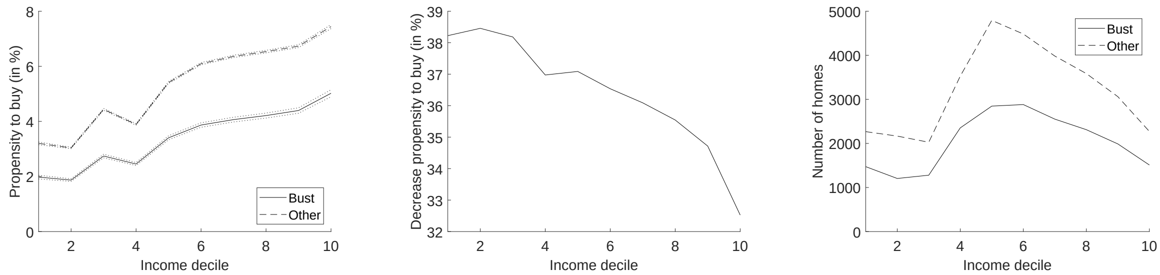


This figure summarizes the impact of age on market entries. The left panel depicts the average model-implied probability to acquire homeownership by age (Propensity to buy). The middle panel depicts the relative decrease in the model-implied probability to acquire homeownership under the bust relative to other states of the housing market cycle (Decrease propensity to buy). The right panel depicts the predicted number of homes bought (Number of homes). The solid lines in the left and right panels show results during the bust, the dashed lines during other periods. The dotted lines in the left panel depict 95% confidence intervals.

homeownership by less than one percentage point, corresponding to a decrease of only about 27 to 33 percent. Simultaneously, the number of potential market entrants generally decreases with age beyond the age of 25. Consequently, the reduction in the number of homes traded for younger households below the age of 30 is about 500 to 700 for every age, while it is below 110 for every age beyond the age of 50. In other words, age is an important factor explaining the differential behavior of households under the recent housing market bust, and younger households' decrease in their propensity to acquire homeownership has led to a large decrease in the number of market entries.

Our theoretical model from section 2 proposes that the propensity to acquire homeownership declines more during bust periods for households with lower income, because for these households making up for large losses on their homes is more difficult. Figure 7 illustrates that in absolute terms, households in lower income deciles reduce their propensity to acquire homeownership less. For instance, in the lowest income decile, the propensity to buy only decreases by about one percentage point, whereas in the highest deciles, it decreases by more than two percentage points. Whereas these absolute changes in percentage points are, e.g., important for understanding the aggregate demand for homeownership, exploring relative changes (in percent as opposed to percentage points) allows for a better assessment of the question which households changed their

Figure 7
Market entries by income deciles



This figure summarizes the impact of income on market entries. The left panel depicts the average model-implied probability to acquire homeownership by income deciles. The middle panel depicts the relative decrease in the model-implied probability to acquire homeownership under the bust relative to other states of the housing market cycle (Decrease propensity to buy). The right panel depicts the predicted number of homes bought (Number of homes). The solid lines in the left and right panels show results during the bust, the dashed lines during other periods. The dotted lines in the left panel depict 95% confidence intervals.

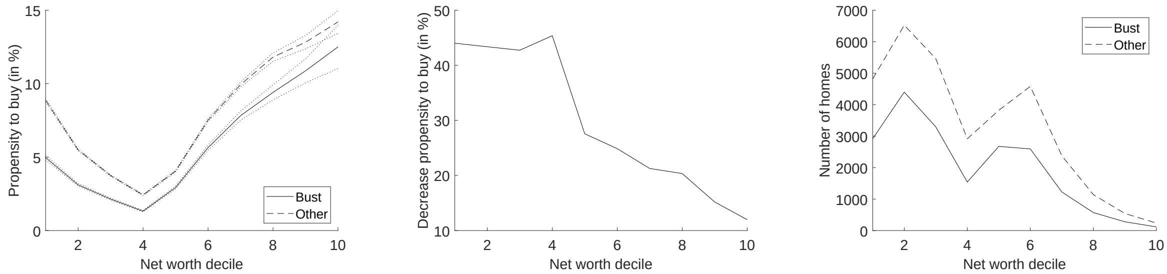
propensity to acquire homeownership under the bust more.

From the middle panel of Figure 7, relative decreases in the propensity to acquire homeownership are highest in the lowest income deciles and decline almost monotonically to the highest ones. In the first income deciles, households reduce their propensity to acquire homeownership by around 38%, whereas in the highest income decile, this value decreases to less than 35%.

For the model-implied reductions in the number of homes traded, the lowest income deciles play a less important role, reflecting that the propensity to acquire a home is relatively low in both bust and other periods. Similarly, the behavior of households in the highest income deciles is less important, reflecting that the absolute number of households in the highest income deciles, that do not yet own a home, is smaller than in other income deciles.

Similar to labor income, from our theoretical model from section 2, households with lower levels of net worth should shy more away from acquiring homeownership during busts than households with higher levels. We investigate the impact of household net worth on the propensity to acquire a home conditional on all other household characteristics in Figure 8. From the left panel, households in the lower net worth deciles are more likely to acquire homeownership than households in the fourth net worth decile, in which the propensity to acquire homeownership is lowest. This may seem counterintuitive at first glance, since intuitively, the propensity to acquire

Figure 8
Market entries by net worth



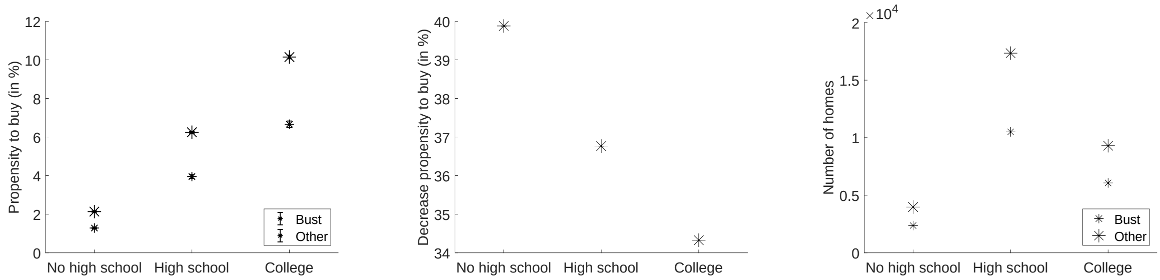
This figure summarizes the impact of net worth on market entries. The left panel depicts the average model-implied probability to acquire homeownership by net worth deciles. The middle panel depicts the relative decrease in the model-implied probability to acquire homeownership under the bust relative to other states of the housing market cycle (Decrease propensity to buy). The right panel depicts the predicted number of homes bought (Number of homes). The solid lines in the left and right panels show results during the bust, the dashed lines during other periods. The dotted lines in the left panel depict 95% confidence intervals.

homeownership should increase with household net worth. However, households in the lowest net worth deciles are often households with high levels of income and debt. That is, backed up by their high income, these households have taken out high loans. Households in the forth net worth decile, on the other hand, are often characterized by a low level of household income and thus a lower ability to take out larger loans. In line with economic intuition, households falling into the highest net worth deciles, i.e., households that are least financially constrained, have the highest propensity to acquire homeownership.

From the middle panel of Figure 8, relative decreases in the propensity to buy are highest in the lowest four net worth deciles with more than 40% and decline monotonically to only about 12% for the highest net worth decile. That is, in line with the prediction from section 2, richer households decreased their propensity to acquire homeownership under the bust less than poorer households.

For households with sufficient savings, the consequences of falling house prices only result in a reduction of their savings and are thus primarily financial. For homeowners with smaller or even negative levels of net worth, falling house prices have consequences extending beyond the financial ones. In particular, households with smaller levels of net worth face the risk that their mortgages exceed the values of their homes after price drops. In that case, these households can-

Figure 9
Market entries by education



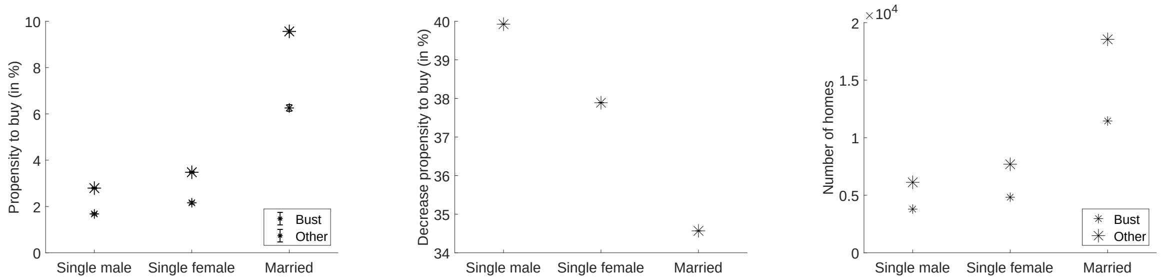
This figures summarizes the impact of education on market entries. The left panel depicts the average model-implied probability to acquire homeownership by education with 95% confidence intervals. The middle panel depicts the relative decrease in the model-implied probability to acquire homeownership under the bust relative to other states of the housing market cycle (Decrease propensity to buy). The right panel depicts the predicted number of homes bought (Number of homes). The small stars depict results during the bust, the large during other periods.

not sell their homes without being left with a seizable amount of debt that – in the absence of the home as a collateral – is subject to a much higher interest rate than a mortgage. Hence, such households are tied to their home and may be unable to, e.g., accept attractive job offers if these offers would require the households to relocate. In addition to the consequences for the individual households, the inability to relocate should also have negative macroeconomic consequences, since the reduction in the mobility of the labor force bears the risk of a less efficient allocation of labor on the macro level.

From the right panel of Figure 8, the richest households are only responsible for a very small number of market entries, reflecting that many of these households already own homeownership and thus do not qualify as potential market entrants.

Our stylized model from section 2 further suggests that households with higher levels of labor income risk should reduce their propensity to acquire homeownership during the bust more than other households. Households with lower education face higher unemployment risk. These households should therefore reduce their propensity to acquire homeownership more than households with higher levels of education. Similarly, banks should be less willing to grant loans to such households in busting housing markets. Likewise, singles face higher labor income risk than married individuals for whom the partner's labor income stream provides a certain protection against

Figure 10
Market entries by marital status



This figures summarizes the impact of the marital status on market entries. The left panel depicts the average model-implied probability to acquire homeownership by marital status with 95% confidence intervals. The middle panel depicts the relative decrease in the model-implied probability to acquire homeownership under the bust relative to other states of the housing market cycle (Decrease propensity to buy). The right panel depicts the predicted number of homes bought (Number of homes). The small stars depict results during the bust, the large during other periods.

huge losses in household income.

Consistent with the generally higher level of background labor income risk, from the left panels of Figures 9 and 10, households with lower education and singles are less likely to acquire homeownership. Matching our model's predictions, the middle panels of Figures 9 and 10 reveal that households with lower levels of education as well as singles decrease their propensity to acquire homeownership under the bust more than households with higher levels of education and married households, respectively.

For the absolute number of market entries by education, the change in the propensity to acquire homeownership of households in which the member with the longest education has a highschool degree is most important, reflecting that from Table 1 this type of education is most widespread. Even though the share of potential market entrants being married is smaller than that of both single males and single females, their generally substantially higher propensity to acquire homeownership implies that their decrease in market entries leads to a relatively high reduction in the number of homes traded.

Households with children reduce their propensity to acquire homewonership during bust-years less than their counterparts without children (not shown in graphical form). This result may reflect that the demand of housing becomes more inelastic once children live in the household.

Consequently, households with children may be less able to time the market and may therefore potentially be hurt more by falling house prices.

5 Robustness

5.1 Current owners

Having illustrated in section 4 how potential market entrants alter their propensity to acquire homeownership under the bust with sociodemographic characteristics, we next turn our focus to current owners. That is, we focus on households that already own a home and ask how the propensity to acquire a new home varies with sociodemographic characteristics for these households between the bust and other periods of the housing market cycle. Unlike for potential market entrants, we do not assume households, that have been homeowners since 1993, to have been homeowners since the age of 22, because households opting for homeownership typically do so at a later age. Instead, we control for the number of years current owners are living in their homes and truncate this value at 11, the maximum number of historical observations for our earliest in-sample observation.[14]

Compared to market entrants, current owners should be more constrained in their decision to acquire a new home, because in contrast to market entrants, current owners typically need to time the sale of their pre-existing home with the purchase of a new one. Similarly, in contrast to potential market entrants, potential current owners are already exposed to house price risk prior to deciding about the acquisition of a new home. Hence, when moving to a new home, they typically change their exposure to house price risk less than market entrants. For all those reasons, we expect the impact of sociodemographic characteristics on the propensity to acquire a new home to be weaker for current owners than for market entrants.

Table 4 summarizes in a similar fashion as Table 3 the average marginal effects of the households' sociodemographic characteristics to acquire a new home. In line with economic intuition, average marginal effects for current owners from Table 4 mostly bear the same signs, but tend

[14]We also explored a setting in which we set the number of historical years of homeownership to the maximum observed value. Our results are structurally robust to this modification.

Table 4
Average marginal effects for current owners

Regressor	(1)	(2)	(3)
Age	-0.00146***	-0.00148***	-0.00147***
	(-100.32)	(-101.34)	(-100.76)
Second net worth decile	-0.00322***	-0.00353***	-0.00289***
	(-7.89)	(-8.66)	(-7.09)
Fifth net worth decile	-0.000529	-0.000669	-0.000897
	(-0.97)	(-1.23)	(-1.66)
Tenth net worth decile	0.0189***	0.0187***	0.0187***
	(38.44)	(36.82)	(36.91)
Logincome	0.00126***	0.00128***	0.00134***
	(11.70)	(11.80)	(12.16)
Single male	-0.0135***	-0.0133***	-0.0127***
	(-40.69)	(-39.92)	(-37.93)
Single female	-0.00641***	-0.00595***	-0.00549***
	(-17.98)	(-16.53)	(-15.20)
Children	-0.00531***	-0.00577***	-0.00536***
	(-22.70)	(-24.56)	(-22.80)
No highschool	-0.0119***	-0.0121***	-0.0125***
	(-37.36)	(-37.99)	(-39.39)
College	0.0118***	0.0120***	0.0125***
	(49.71)	(49.56)	(51.48)
Owning span	0.00138***	0.00133***	0.00135***
	(39.43)	(37.86)	(38.53)
Bust	-0.0190***	-0.0195***	-0.0271***
	(-79.68)	(-81.80)	(-57.49)
Other controls	YES	YES	YES
Municipality-fixed-effects	NO	YES	YES
Year-fixed-effects	NO	NO	YES
Observations	6,017,723	6,017,723	6,017,723

This table depicts average marginal effects for the likelihood of a homeowner purchasing a new home. *Age* is the age of the oldest member in the household. *Second/fifth/tenth net worth decile* is an indicator for whether the households' net worth is in the second/fifth/tenth decile of the net worth distribution in the total population; dummies for all other net worth deciles are also included in our regressions. *Single female (male)* is an indicator for whether the household only has one female (male) adult household member. *Children* is an indicator for whether children below the age of 18 are living in the household. *No highschool* is an indicator for whether the household member with the longest education has no highschool education. *College* is an indicator for whether the household member with the longest education has a bachelor's degree. *Owning span* is the number of years the household members are living in their current owner-occupied home. *Other controls* are the remaining net worth deciles, a missing education dummy, an indicator for whether a household was newly formed, the indicator for whether a household was newly formed interacted with whether the household is two-headed, an indicator for whether at least one family member has owned an owner-occupied home in the past, and an indicator for whether household income grew by more than 10% in the previous period. The constant is not reported for brevity. t-statistics are reported in parentheses. *, **, and *** denotes significance at the 5%, 1% and 0.1% level, respectively. Standard errors are clustered on the household level.

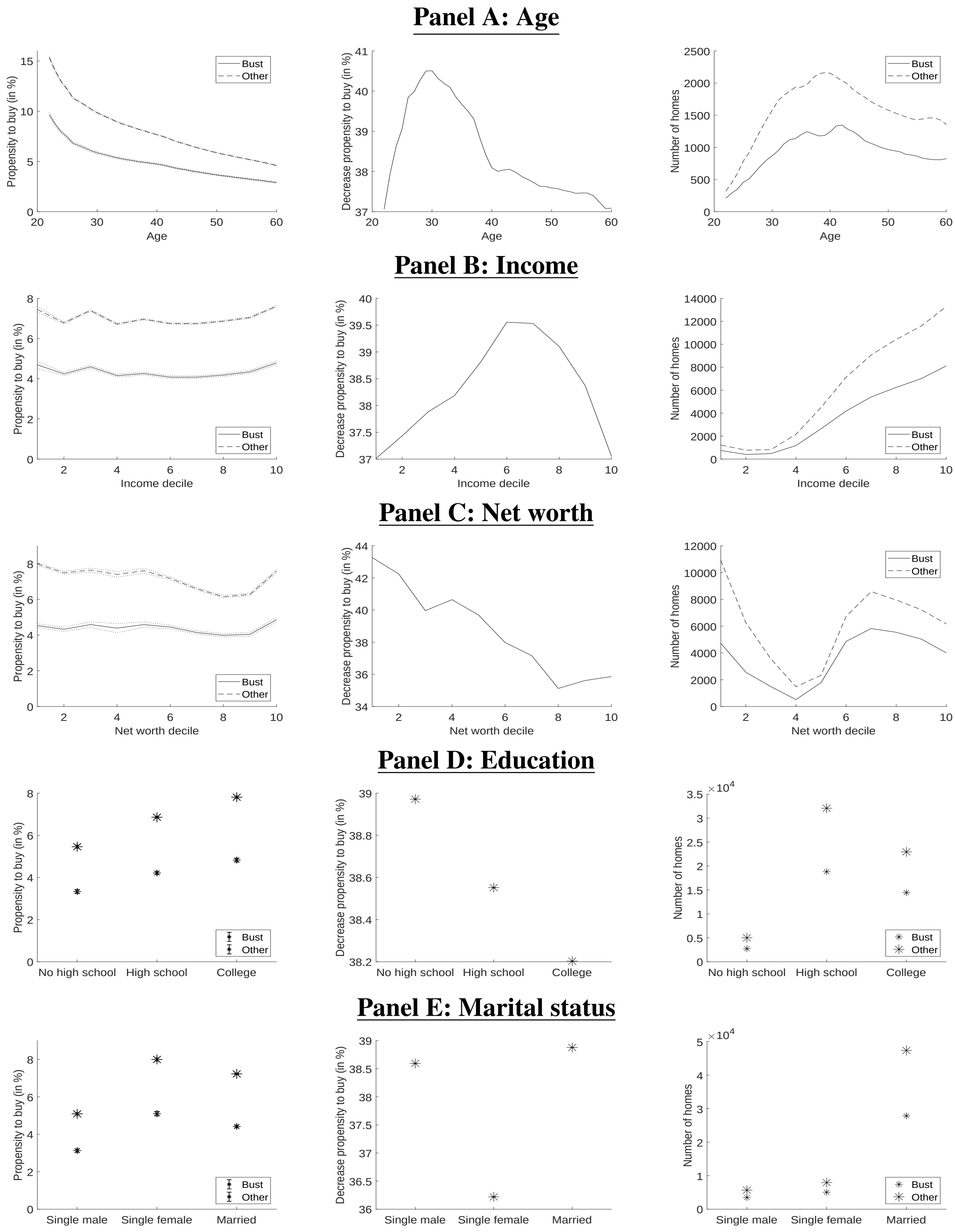
to be of a smaller order of magnitude than those for potential market entrants from Table 3. Coefficients for the length of the period of being renter/owner and whether children are living in the household carry different signs, suggesting that households with children are more likely to change homeownership status from renter to owner, but less likely to move to a new home when already owning one. In other words, sociodemographic characteristics affect the propensity to acquire a home for current owners in a qualitatively similar way as for potential market entrants. Yet, the strength of the effects is usually dampened, which makes intuitive sense, since current owners typically change their exposure to house price risk less when acquiring a new home than potential market entrants do and typically want to time the acquisition of a new with the sale of their current place.

Having established that average marginal effects of sociodemographic characteristics of current owners are qualitatively similar to those of potential market entrants, we next turn to investigating the average model-implied probabilities to acquire homeownership by various sociodemographic characteristics. Figure 11 summarizes in a similar fashion as Figures 6 to 10 the impact of sociodemographic characteristics on the propensity to acquire a new home. The left panels depict the average model-implied probability to acquire a new home with 95% confidence intervals. The middle panels depict the relative decrease in the model-implied probability to acquire a new home under the bust relative to other states of the housing market cycle (Decrease propensity to buy). The right panels report the predicted numbers of homes acquired (Number of homes). Panel A reports results by age, Panel B by income, Panel C by net worth, Panel D by education, and Panel E by marital status.

Our results from Figure 11 show that similar to potential market entrants, current owners decrease their propensity to acquire a new home more under the bust when endowed with low net worth (Panel C) and when having a shorter education (Panel D). Likewise, the propensity to acquire a new home under the bust is reduced less at older age (Panel A).

From the middle graph of Panel B and in contrast to potential market entrants, households in the lower income deciles reduce their propensity to acquire homeownership less than households in the sixth net worth decile. Yet, quantitatively, the effects are very small and the implied number

Figure 11
Purchases of current owners



This figure impact of various sociodemographic characteristics on current owners' impact to acquire a new home. The left panels depict the average model-implied probability to acquire a new home with 95% confidence intervals. The middle panels depict the relative decrease in the model-implied probability to acquire a new home under the bust relative to other states of the housing market cycle (Decrease propensity to buy). The right panels report the predicted numbers of homes acquired (Number of homes). Panel A reports results by age, Panel B by income, Panel C by net worth, Panel D by education, and Panel E by marital status.

of trades is low – particularly for the first three net worth deciles.

From the middle graph of Panel E and again in contrast to the results for potential market entrants, married owners reduce their propensity to acquire a new home under the bust more than singles – particularly female singles. Married individuals that already live in an owner-occupied home are typically more rooted to their local environment than singles. Hence, for married households, postponing the move to another owner-occupied home in presumably the same local environment until the market has stabilized, is generally easier than for singles that are more likely to relocate over larger distances.

5.2 Abandoning homeownership

Having established that market entrants' propensity to acquire homeownership varies remarkably with sociodemographic characteristics between bust and other periods, we next turn our focus to current owners. That is, in this section we focus on households that already own an owner-occupied home and investigate which characteristics drive their propensity to leave the housing market by changing homeownership status from being a home-owner to being a renter. We control for the number of years of historical homeownership as in Section 5.1.[15]

Empirically, ask prices of potential sellers are higher when they are facing (nominal) losses (Genesove and Mayer, 2001; Andersen et al., 2019). This finding has two implications. First, it suggests that sellers are reluctant to realizing nominal losses. Second, since the share of households facing nominal losses increases in busting markets, it can help understand the decrease in trading volume in these stages of the housing market cycle.

Even though it is natural to also investigate the supply-side of the housing market under the bust, it is important to note that the housing market bust period was a buyers' market in which a relatively small number of households interested in acquiring homeownership met a relatively large number of households wishing to sell their home. Hence, the impact of households wishing to leave the housing market on the evolution of house prices is likely to have been smaller under the bust than that of market entrants. Simultaneously, unlike in the US (e.g., Lambie-Hanson

[15]Again, our results are structurally robust to setting the number of historical years of homeownership to the maximum observed value.

et al., 2019, Mills et al., 2019), there is no evidence indicating that corporate investors changed their investment activity in residential real estate in Denmark.

Again, we want to exclude cases in which households are only temporarily moving to a rented place between the sale of their old home and moving into their new home. Consistent with our proceeding for market entrants, we therefore require potential exiters to be homeowners at time t, but not at time $t + 1$ and neither at time $t + 2$ whenever this information is available in the data. In contrast to our proceeds for market entrants, we have to omit the last year in our sample for which no information about the homeownership status at time $t + 1$ is available.

Similar to our results for market entrants from Table 2, our sociodemographic variables again affect the propensity to leave the housing market in a statistically significant way (results now shown here). Table 5 depicts in a similar manner as Table 3 the average marginal effects of our sociodemographic variables on the propensity to abandon homeownership.

As for market entrants, Table 5 documents that the propensity to abandon homeownership decreases with age, reflecting that older households are generally less likely to move. Otherwise, the marginal effects for abandoning homeownership from Table 5 typically switch signs compared to the results for market entrants from Table 3. Poorer households are less likely to acquire homeownership, but more likely to abandon it. Similarly, households with higher income are more likely to acquire homeownership and less likely to abandon it. Likewise, singles acquire homeownership less often, but revert their homeownership status to becoming renters more often. Finally, the propensity to acquire homeownership increases with education length, while the propensity to abandon homeownership decreases.

While the results in Table 5 stress the general economic relevance of sociodemographic characteristics for the propensity to abandon homeownership, they do not allow us to address the question whether the propensity to abandon homeownership in different states of the housing market cycle varies with household characteristics. We investigate this question in Figure 12 that depicts in a similar fashion as Figures 6 to 10 the average model-implied probabilities to abandon homeownership.

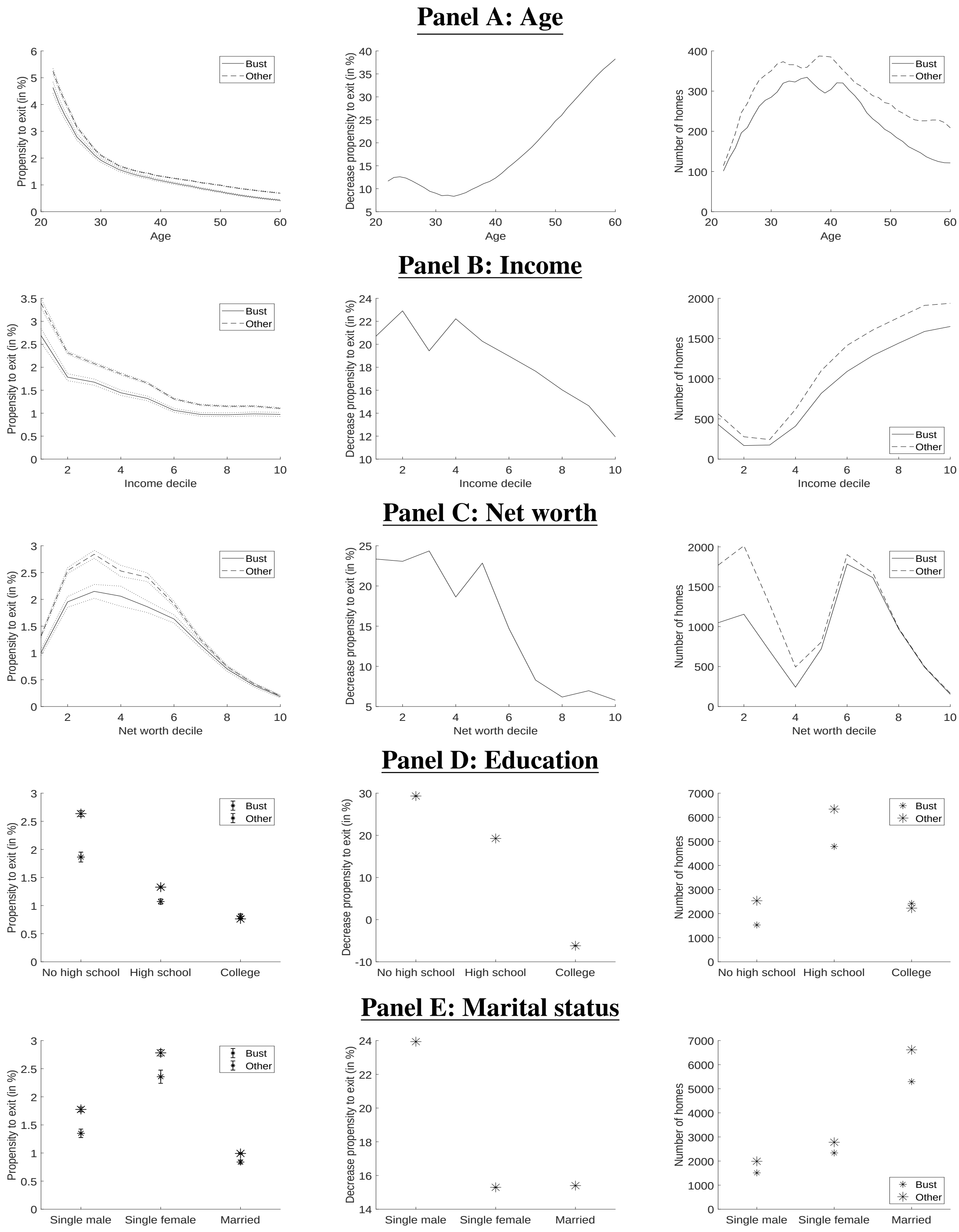
From the middle graph of Panel A, younger households decrease their relative propensity to

Table 5
Average marginal effects for abandoning homeownership

Regressor	(1)	(2)	(3)
Age	-0.0000577***	-0.0000199***	-0.0000200***
	(-9.62)	(-3.30)	(-3.32)
Second net worth decile	0.00354***	0.00465***	0.00456***
	(15.78)	(19.49)	(19.15)
Fifth net worth decile	0.00176***	0.00228***	0.00230***
	(6.50)	(8.02)	(8.09)
Tenth net worth decile	-0.0110***	-0.0121***	-0.0121***
	(-65.06)	(-72.12)	(-72.00)
Logincome	-0.000665***	-0.000675***	-0.000683***
	(-24.87)	(-25.87)	(-26.13)
Single male	0.0159***	0.0157***	0.0158***
	(67.85)	(67.28)	(67.33)
Single female	0.0273***	0.0262***	0.0262***
	(93.07)	(90.62)	(90.66)
Children	0.000941***	0.00135***	0.00135***
	(8.51)	(12.09)	(12.11)
No highschool	0.00320***	0.00390***	0.00389***
	(21.02)	(24.51)	(24.48)
College	-0.00184***	-0.00266***	-0.00266***
	(-17.62)	(-25.74)	(-25.70)
Owning span	-0.000345***	-0.000259***	-0.000262***
	(-25.13)	(-18.70)	(-18.89)
Bust	-0.00332***	-0.00252***	-0.00219***
	(-30.66)	(-19.56)	(-8.36)
Other controls	YES	YES	YES
Municipality-fixed-effects	NO	YES	YES
Year-fixed-effects	NO	NO	YES
Observations	5,198,549	5,198,549	5,198,549

This table depicts average marginal effects for the likelihood of a homeowner abandoning homeownership. *Age* is the age of the oldest member in the household. *Second/fifth/tenth net worth decile* is an indicator for whether the households' net worth is in the second/fifth/tenth decile of the net worth distribution in the total population; dummies for all other net worth deciles are also included in our regressions. *Single female (male)* is an indicator for whether the household only has one female (male) adult household member. *Children* is an indicator for whether children below the age of 18 are living in the household. *No highschool* is an indicator for whether the household member with the longest education has no highschool education. *College* is an indicator for whether the household member with the longest education has a bachelor's degree. *Owning span* is the number of years the household members are living in their current owner-occupied home. *Other controls* are the remaining net worth deciles, a missing education dummy, an indicator for whether a household was newly formed, the indicator for whether a household was newly formed interacted with whether the household is two-headed, an indicator for whether at least one family member has owned an owner-occupied home in the past, and an indicator for whether household income grew by more than 10% in the previous period. The constant is not reported for brevity. t-statistics are reported in parentheses. *, **, and *** denotes significance at the 5%, 1% and 0.1% level, respectively. Standard errors are clustered on the household level.

Figure 12
Market exits



This figure summarizes the impact of various sociodemographic characteristics on current owners' impact to abandon homewonership by moving from an owner-occupied to a rented place. The left panels depict the average model-implied probability to abandon homeownership with 95% confidence intervals. The middle panels depict the relative decrease in the model-implied probability to leave the housing market under the bust relative to other states of the housing market cycle (Decrease propensity to buy). The right panels report the predicted numbers of homes acquired (Number of homes). Panel A reports results by age, Panel B by income, Panel C by net worth, Panel D by education, and Panel E by marital status.

abandon homeownership less than older households. In other words, the decrease in homeownership among younger households from Figure 5 is not only driven by the decrease in demand for homeownership from Figure 6, but simultaneously by an increase in the supply of homes of younger households that have a higher propensity to abandon homeownership than older households.

The middle graph of Panel B indicates, that households with lower income decrease their propensity to exit the market less during the bust. At first glance, this result may seem surprising, since low-income households should be more affected by losses in the values of their homes than high-income households and therefore have a stronger incentive to sell their homes. However, low-income households are more likely to have the value of their mortgage exceeding the remaining value of their home – particularly during the bust. That is, low-income households are more likely to be locked into their homes and cannot sell them without ending up with a substantial amount of bank debt that – in contrast to a mortgage – is not collateralized and thus subject to a substantially higher interest rate. Such households therefore have a stronger incentive not to sell their homes.

Panel C indicates that under the bust, households in the lowest net worth deciles decreased their propensity to abandon homeownership more than richer households. Similar to low-income households, households with low net worth are more likely to be locked into their homes – particularly during the bust. Hence, households in the lowest net worth deciles also have a strong incentive not to sell their homes.

From Panel D, households with lower levels of education reduce their propensity to exit the market more often. Households with lower levels of education face a higher probability of job loss and, conditional on being unemployed, are on average unemployed over a longer period. Hence, they are more likely to be locked into their homes – particularly during the bust. Hence, these households also have a stronger incentive not to sell their homes.

From Panel E, single males reduce their propensity to abandon homeownership under the bust less than single females and married. This results reflects that single male homeowners are on average endowed with lower levels of net worth than single females and married ones. Simultaneously, the share of single males with a negative level of household net worth is higher than for single females, suggesting that they are more likely to be locked into their homes and therefore refrain from selling it.

6 Conclusion

We exploit a large high-quality data set covering the entire Danish population to investigate the micro-level behavior of households during housing market busts. The Danish data seems ideally suited for such an investigation, because it contains detailed background level information about all Danish households and Denmark experienced a housing market bubble that is remarkably similar to its US counterpart.

Our results show that in bust periods, households that are more affected by falling house prices reduced their likelihood of acquiring homeownership more than other households. Particularly, younger households, households with lower net worth, income, or shorter education, as well as singles shy more away from acquiring homeownership. Simultaneously, younger households are more likely to abandon homeownership during bust periods.

The reduction in younger households' willingness to acquire homeownership and their higher willingness abandon it under the recent housing market bust is likely to have played a major role in explaining the huge inter-generational shift in homeownership from younger to older households during the bust and its aftermath. Whereas homeownership in the general population remained fairly stable at around 55%, the homeownership rate of younger households with the oldest member being less than 30 years showed a remarkable decline from about 22% before house prices fell dramatically to less than 18% in 2010. Similarly, the homeownership rate among households with the oldest member being 30 to 39 also decreased. During the same time, the homeownership rate of older households slightly increased.

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Chapter 4

Investments in children: Wealth shocks and child education

Investments in children: Wealth shocks and child education.*

Julie Marx†

Abstract

Family wealth and offspring achievements are highly correlated, but the causation is not clear. This study examines both the causal impact and the mechanisms of which family wealth can affect child outcomes. Using bequests from deceased grandparents, I find that the extra parental liquidity neither affects grades, high school and college enrollment, or high school drop out rates of children. Parents do not send offspring to different schools, move to better neighborhoods, or reduce their own nor their children's work time. The additional wealth is spent on household consumption through bigger houses, cars, and holiday homes. The results suggest than in a system with universal education, public funds are probably better spent on improving school quality than making transfers to parents.

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†Copenhagen Business School, Email: jma.fi@cbs.dk.

1 Introduction

Education is an essential determinant of later-in-life success. Investment in the education of children affects their future income prospects, psychical- and mental health, criminal activity, wealth, and even portfolio returns (Elango et al.,2016, Girshina, 2019, Heckman, 2006, Heckman et al., 2018). The intergenerational link between parent wealth and child education is strong (Adermon et al., 2018, Boserup et al., 2018, Landersø and Heckman, 2017, Shanks, 2007, Wiborg, 2017). This study asks the questions whether parental wealth is still of importance for children's achievements, once education is provided virtually for free. Further, it examines channels by which parents could choose to better the odds of their offspring.

Identifying the causal effect of parental wealth on child education and achievements is challenging. An inter-generational link between parental wealth and child education could both reflect the shared innate ability, culture, and networks shared between parents and children, or differently be the result of wealthier parents' better opportunity to invest in their children. Better finances allow parents to invest in their families in numerous ways. Parents both choose where to live, how much to work, whether to buy additional tutoring or how much to subsidize children financially – all decisions which demand resources that not all parents have. At the same time, financial distress potentially causes stress in both parents and children, which in turn could have negative consequences for the quality of parenting and child cognition and learning. (Willingham, 2012)

Using high-quality Danish administrative records, I examine if wealth transfers from the termination of grandparent estates affect educational outcomes of grandchildren using grades from ninth grade and enrollment up to university as achievement outcomes. I apply a combination of coarsened exact matching and nearest-neighbor matching to match families who inherit while the child is less than 10 years old to families who do not inherit (Iacus et al., 2011, 2012). I find no or small adverse effects of inherited wealth on grade performance as well as enrollment drop out rates up to university. The outcome is independent of inheritance size and is not reversed for large bequests, suggesting losing a grandparent has an adverse effect, outweighing the mere wealth shock from grandparents.

While the Danish educational system provides free (and also heavily subsidized) universal education, parents can invest in the human capital of their children in numerous other ways than direct school costs. If wealth not seem to have a direct impact on educational outcomes, do parents not invest in improving their children's opportunities? To answer this question, I examine parents' housing investments, family investments, and car consumption. In studying housing, I look at the decision to move and the neighborhood characteristics and house size change of movers as well as the propensity to move school. In studying family investments, I proxy parent work time by income growth as well as divorce rates and children's tendency to have a youth job. Lastly, I examine car consumption and purchases of holiday homes as examples of parental spending that should have little impact on child development.

While households inheriting large amounts from grandparent estates do seem to move to bigger homes, they do not relocate to better neighborhoods, and only to a small extent let the children move schools. Parents also do not adjust their own or their children's work time, but parents who receive moderate bequests do show lower divorce rates. Parent beneficiaries mostly respond to a bequest by investing in cars and holiday homes, which may benefit children utility, but also may explain why there is little effect on educational outcomes. The results suggest that a wealth shock to parents do not transfer into investments in child education, and therefore also do not affect educational outcomes

Several other studies have used windfall wealth to examine child outcomes. Bleakley and Ferrie (2016) study the effect of random distribution of land in a 1832 reform in the U.S., and finds no long term effect on children's wealth, income, and literacy. Ager et al. (2019) study the impact of the emancipation of American slaves for slave-holding families and finds that after only one generation, the shock had neutralized. Cesarini et al. (2016) exploit large prizes in a Swedish national lottery and show that the windfall wealth has some effect on child health, but have no overall impact on other child outcomes, including scholastic performance and skills up until secondary school.[1] I add to the literature by examining

[1]An even more extensive literature has focused on the impact of income, with general agreement that

whether parents do to try to improve children's outcome through decisions which should help to improve the odds of the offspring. I find that parents do not, but turn inherited wealth into consumption for the family.

The paper is structured as follows: Section 2 describes the institutional setting in Denmark and introduces the high-quality Danish register data. Section 3 discusses the empirical approach, including the matching procedure used to secure identification. Section 4 presents the results and Section 5 concludes.

2 Danish Data

To identify how wealth windfalls through estate termination translate into investment in children's opportunities I use a myriad of administrative data sets: The civil registration database for household definitions, the education register for educational achievements, the income register for availability of resources, and the death register for estate terminations. I also make use of the employment register and the car register, as well as property transactions, housing and crime registers for examining youth work, consumption, and neighborhood characteristics. This section describes the main variables and data sources, as well as the institutional setting.

As the base of the data collection, the civil registration data links children to parents, allowing me to identify the family network and its characteristics from children to grandparents.[2,3] It also provides basic demographics such as birth year, gender, marital status,

parents with higher income invest more in their children and that their children are more skilled. However, the direct causal effect of income is less clear (Heckman and Mosso, 2014). Using measures such as child care price cuts, firm closings, and different kinds of IV, studies find significant positive effects of parent income on test scores, junior high school GPA and child income. (Akee et al., 2010, Black, et al., 2014, Dahl and Lochner, 2012, Duncan et al., 2011, Milligan and Stabile, 2011, Oreopoulos, 2008). Effects are strongest for disadvantaged families; in fact Løken et al. (2012) finds a concave relationship between family income and child outcomes. However, using different kinds of instrumental variables estimation and fixed effects analysis, other studies find no or little effect of income on child school-age test scores, years of schooling, and child income (Blau, 1999, Dooley and Stewart, 2004, Løken, 2010, Sacerdote, 2007, Shea, 2000)

[2]The children-parent link exists only to a limited extent for individuals born before 1968, which means that I am not able to identify grandparents of all children in the time period.

[3]I ignore the composition of the household children live in, meaning that 'a family' refers to a child and its parents, irrespective of whether the parents live together or apart, and where the child lives. I also ignore potential effect of stepparents.

and an anonymous address code for geographical location.

2.1 Educational attainment in Denmark

In Denmark education up to and including university is government-funded and even subsidized so that students from the age of 18 get a monthly allowance from the government. Up to ninth grade, education is also compulsory.[4] More than 98 percent of Danes in the 1984 to 1988 cohorts finished ninth grade, 58 percent graduated high school or got similar level degree, and 46 percent got a college degree (bachelor or higher).[5]

Ninth grade of elementary school is completed with grades based on in-class performance as well as oral and written exam grades. Acceptance into high school and other secondary education is guided by ninth grade grades, but sorting into specific high schools is not based on grades.[6] In all education levels grades are -3, 00, 02, 4, 7, 10, 12, with 02 and above being passing grades and 7 being the norm. Appendix Figure A.1 shows the distribution of grades. [7]

The Danish Ministry of Education collects detailed education records of both ongoing education and completed degrees, registered on a yearly basis, allowing me to identify both high school dropouts and enrollment into university. For the years 2002 to 2019, they also collect all individual grades obtained in eighth to tenth grade, by subject and type (exam or in-class participation).

To examine grade performance, I calculate a simple average of all grades of all types in Math, Danish and English for each child graduating ninth grade between 2002 and 2019. To determine further education, I use the detailed DISCED-15 codes for ongoing and finished education provided by the Ministry of Education. All individuals who was ever enrolled in high school, are classified as high school enrollees. All individuals who was enrolled in high school but did not have a high school degree six years after are classified as high school

[4] If a child is not sent to a public or private school the parent's are obliged to conduct home schooling.

[5] Source: Statistics Denmark's data bank, Statistikbanken.dk, statistic HFUDD11

[6] Rules have changed during the time period in the direction of more reliance on ninth grade grades in determining "readiness for high school"

[7] The grade scale was changed in 2007, and all grades reported are re-scaled to the new scaling.

dropouts.[8] University enrollment is classified by the same codes for ongoing education and cover all individuals enrolled in a bachelor degree or higher.

Like in most other countries, educational outcomes of children are highly correlated with the socioeconomic background of parents (Gensowski et al. 2020, Landersø and Heckman, 2017). Looking at the Danish data for 2018, 45 percent of 30 year olds with a college degree, were from families with college degrees. For 30 year olds without college degrees the same number was 20 percent. In order to control for selection into education, I need information on family background.

2.2 Family resources

To describe the family background I focus on parent's income, parent's wealth, parent's education, and grandparent's wealth. Individual wealth and income data are from the Danish tax authorities and is mostly third-party reported by employers or banks. Wealth is reported at the end of the year, while income is the yearly total. Net wealth cover bank deposits, stock and bond holdings, real estate, bank debt, and mortgages. I use the aggregated income of the mother and the father as well as the aggregated wealth.

Parent education information is from the Ministry of Education, as described in Section 2.1. I use the highest achieved education among parents, and categorize it into four groups: no high school, high school, college, and master degree or higher.

Several studies have shown that the socioeconomic status of the extended family, including grandparents, impact child development independently of the parents, especially in low-SES families.(Jæger, 2012, Mare, 2011, Laury, 2006, Wiborg, 2017) As a measure of this extra type of family resource - and to proxy for expected inheritance - I create a measure of "potential inheritance". Potential inheritance is the size of the expected inheritance if all grandparents were to die at once. I.e. for each living grandparent, I divide their total wealth by the number of living beneficiaries (children). A family's potential inheritance is

[8] A high school degree usually takes three years, but some programs offer four years. A student entering high school in August 2002 will normally graduate in June 2006 and the degree will be registered by January 2007, implying a five year gap between year of enrolling and year of registering. I allow one extra year before I classify an individual as dropping out.

the total of each grandparent's wealth split by each their number of children.

2.3 Shocks to wealth

To examine the effect of wealth shocks, I use the shock to liquidity coming from bequest from deceased grandparents. Although a bequest is not unexpected, the exact timing (and thus size) of it is somewhat random. Parents know that they at some point will inherit, but not whether it is sooner or later.[9]

I identify time of death of grandparents through death records. When an individual in Denmark dies, the death is reported to the Central Office for Personal Registration (CPR Registeret, the civil register) and to the probate court (Skifteretten), who is responsible for settling the estate.[10] The estate first covers taxes and funeral related costs, and the residual is then paid out to the beneficiaries. Beneficiaries can renounce the inheritance if they wish, which is relevant if the deceased has negative wealth. I.e. children are not forced to take over parent's debt.

If the deceased has a will, it will be in effect. However, by law 25 percent of the inheritance is reserved to any spouse and children. If there is no will, the estate will be settled according to the Danish Inheritance Act. Default beneficiaries are spouses and children, who will share the inheritance equally.[11] In many cases, however, the spouse will decide to retain in undivided possession of the estate, implying that settling of the estate is postponed until the spouse dies or remarries. The decision have to be approved by any children of the deceased that are not children of the spouse.

[9] Although not exactly the same, this approach somewhat resemples the identification strategy in Fadlon and Nielsen (2019), who studies the effect of a health shock by comparing families who experience a health shock to families who experience the same shock, but a few years later.

[10] The probate court advertises for creditors in The Danish Gazette (Statstidende) and creditors have eight weeks to report any claim to the estate. Following the eight weeks, assets are either liquidated or assessed by the probate court to determine the net worth of the estate and to pay estate tax.The estate tax is 15 percent for any estate value above a yearly determined threshold. The threshold was DKK 301,900 in 2020. Estates of deceased who are already in undivided possession of the estate from a deceased spouse can double the threshold. I.e. in these cases the 2020 threshold is 603,800. For now, I ignore estate taxes, since I do not know whether a deceased is in undivided possession of the estate. A later version of the paper will address the robustness of the results with respect to the estate tax.

[11] If the deceased has no living spouse or descendants, beneficiaries are in the following order: 1) parents 2) siblings 3) grandparents 4) parent's siblings 5) the Danish Treasury.

To identify bequests I exploit the civil register as well as the death register and the income and wealth register. A downside of the data is that it does not have direct information on bequests. However, applying few assumptions and restrictions lets me construct a good measure of potential bequest, very much in line with Andersen and Nielsen (2011) and Boserup et al. (2016). To make sure that the death is likely to lead to a bequest, I focus on deaths of grandparents, who are unmarried (including divorced and widowed) at the time of death, assuming that their wealth will then be transferred to their children. To establish the size of the bequest, I use the net wealth of the deceased from December 31st in the year before death, divided but the number of living children. By doing that, I assume that the estate is settled according to the Danish Inheritance Act and not a will.[12] Net wealth includes all financial assets and liabilities, i.e. bank deposits, bank loans, stock holdings, mortgages and the tax-assessed value of any real estate, but excludes private loans and the value of durable goods, such as cars, furniture, art, and jewelry. I ignore funeral costs since I assume that the value of durable goods and other unregistered assets in most cases will cover the funeral cost.

Gathering information on bequest size, family background and educational outcomes lets me study the impact of bequests on child education. But to examine the channels through which parents can impact child education, I need data on parents' investments following the bequest.

2.4 Potential investments

When parents inherit they have improved opportunity to invest in the education of their children, but they can also choose to make other investments or to consume the windfall wealth. Investment in child education could be moving to a better neighborhood or to increase parent's time at home as well as reducing youth employment. Examples of investments that has no clear influence on child education are bigger homes, cars, and holiday

[12] According to a survey by YouGov and the Danish NGO "Det Gode Testamente", only 17 percent of the Danish population had a will in 2017 (https://www.cancer.dk/nyheder/nyt-initiativ-skal-fa-flere-danskere-til-at-skrive-testamente/).

homes.

Landersø and Heckman (2017) suggest that the sorting of families into neighborhoods and schools by levels of parental advantage partly explain why family background - despite the universal nature of the Danish educational system - is still a significant predictor of educational outcomes. I examine whether parents who by inheriting get the chance to move to a difference neighborhood and school, actually do so. To study moving decisions I use the anonymized address codes from the civil registers to identify all households who move address as well as the subgroups that move to a different shire or different municipality.[13] For neighborhood characteristics I focus on shire-specific mean income, real estate prices, and crime rates.[14]

In addition, since crowded housing with little room for quiet study time discourage learning (Willingham, 2012), I study whether families who move, get more space. For that I use the housing register (Bygnings- og Boligregister, BBR) to establish the three-year change in interior size of the home, following a bequest.

Moving to another neighborhood will impact child education the most if it also includes a change of school, but short-distance moves may not result in a new school. In spite of extensive regulation and redistribution of municipality budgets, public elementary school quality in Denmark still correlate with the social-economic status of local area families. Public school curriculum follow national standards, there is not a strong link between local area public finances and public school expenditures, and teacher wages follow national collective agreements, making it impossible to recruit high-quality teacher by offering higher wages. However, strong sorting of both children and teachers takes place. School access

[13]Denmark has 98 municipalities and more than 2,000 shires.

[14]Using the income register, I calculate mean income of adults in a shire. For families moving shire, I compare the mean income of the old shire to the mean income of the new shire, both in the year following the move. For real estate prices, I compare mean square meter prices of sold properties in the old shire to mean square meter prices of sold properties in the new shire, both also in the year following the move. Data on property transactions are from the Danish Tax and Customs Administration (SKAT) and covers all transactions of single-family owner-occupied housing from 1992 to 2017. I link it to the housing register (Bygnings- og Boligregister, BBR) to find housing sizes and determine average square meter prices of sold properties in each shire. Using the crime register, I count non-traffic-related criminal sentences per 1,000 inhabitants in a shire and compare the statistic in the old shire to the new shire, both in the year following a move.

is determined by school catchment areas, causing homogeneous student compositions, and high-quality teachers sort into schools with children from affluent homes. The result is that there significant differences in school quality between local neighborhoods. (Gensowski et al., 2020). I examine whether children whose parents inherit are more likely to change schools, possibly to schools of higher quality. Data is from The Ministry of Education and includes the ID of the school in which a student is enrolled which lets me identify children who move school within a three-years window.

Besides moving, parents inheriting large amounts also have the chance to reduce stress and convert the extra wealth into family time, by reducing their own working hours or by outsourcing house work. Extra financial flexibility may also affect divorces through less financial concerns and better opportunities for outsourcing house work, traveling and enjoyment. Heinesen (2019) shows that divorces have direct negative impact on educational outcomes of children, while Hankins and Hoekstra (2011) find no effect of income on divorces. Thus, investments in better relationships can potentially affect children educational outcomes, but it is not clear that these family investments will take place. To examine family investments I focus on parent work time and divorces. I use three-year income growth as a proxy for work time and effort and I study the three-year propensity for married couples to get divorced.[15] Data is from the income register and the civil register.

In line with parent time consumption, child time use is also of importance for education. More financial flexibility allows parents to lend extra financial support to their teenagers, potentially reducing youth work and leaving more time to study.[16] Danish children are allowed to work from the age of 13, but under certain restrictions on work time and conditions. At age 16 the restrictions on jobs are eased and at the age of 18 no special restrictions exist. I measure youth work using labor income from the employment data base (IDA). I mark all children under 18 years old as having a youth job if their labor income surpasses

[15]Statistics Denmark provide some estimates of work time, based on pension ("ATP") payments, but they only record contractual work time, which can be very different from actual work time, since they do not include overtime.

[16]Boserup et al. (2018) finds that direct transfers from parent play an important role in explaining adult wealth inequality and Keane and Wolpin (2001) finds that well-educated parents subsidize their children in college more than lesser educated parents do, but that is has only minor effects on schooling.

the age-specific 5th percentile of children with a labor income. At 13 years old, 44 percent have some kind of youth employment. At 16 years old it is 76 percent and at 18 years old, 78 percent are employed.

Parent may also choose to consume a wealth shock or to make investments that do not benefit the children. Examples of this are car consumption and investments in holiday homes. Buying a better or an extra car may improve family (or parent) welfare, but it is hard to imagine it impacting child education. I.e. it is a example of private consumption of the parents. I use estimates of family car assets to determine the three-year absolute change in the value of all cars in the family following an inheritance.[17] Likewise, buying a holiday home potentially benefits the family, but it is not clear how it would affect child education.[18] I use the ownership register and the housing register to determine each parent's holdings of recreational homes, and to establish the value I take the public valuation, set by the tax authorities for tax purposes. I then find the three-year absolute change in parent's total value of holiday homes.

With all outcome variables, potential investments, and background characteristics in place, I still need to ensure correct identification of wealth effects. The next section describes my approach.

3 Sample Selection and Identification

I identify all children whose parents inherit from their parents while the child is still under 10 years of age. I restrict the sample to children who graduates from ninth grade between 2002 and 2019. Of 1,494,067 ninth grade graduates, 476,420 lose a grandparent before turning 10 years old.[19] Of the 476,420, in 131,838 of the cases, the grandparent was unmarried, divorce

[17]From on the Danish vehicle registration system, Statistics Denmark knows production year, brand, model, type, fuel type, engine effect and gear type as well as ownership of cars in Denmark. Using that data, Statistics Denmark estimate the market value of each household car holdings, under the assumptions that the car is sold to a professional car dealer in a "clean" transaction and that the car has average milage and level of wear and tear for equivalent cars.

[18]"Summerhouses" are a frequently vacation accommodation in Denmark, and is usually available for short term rent, but about 8 percent of households (in 2017) owns their own.

[19]I choose to restrict the sample to children who lose a grandparent before turning 10 years old, because this leaves time for an inheritance to potentially have an effect before the child graduates ninth grade.

or widowed, terminating the household and leaving the estates to the beneficiary.

For each child in the sample, the average inheritance of the parents was 263K DKK (35K EUR), with 84 percent inheriting less than 500K DKK (67K EUR). 12 percent (16,166) inherited 500K to 1.5M DKK (67K-201K EUR) and 4 percent (4,975) inherited more than 1.5M DKK (201K EUR).The median inheritance was 28K DKK (3.8K EUR). Appendix Figure A.2 shows the distribution of inheritance size. All amounts are reported in 2015 levels, adjusted by the Danish Consumer Price Index. To put the inheritance size into perspective, the median parental income in the sample is 657K DKK and a average one-family house traded for 1.5M DKK in 2015. [20]

Table 1 shows descriptive statistics for children and their families at child age zero and in the year of ninth grade graduation. At the time of the child's birth, parents who later come to inherit are slightly older and slightly richer (in both income and wealth) and have higher potential inheritance than other parents, but are on similar wealth levels. At graduation, after inheriting, the same differences remain, although wealth is much higher and the number of living grandparent as well the size of potential inheritance is now naturally much smaller among the beneficiaries than the potential controls. Ninth grade grades are similar among the beneficiaries and the potential controls with an average of 6.55-6.57. Nonetheless, Table 1 highlights the importance of matching beneficiaries to similar families.

[TABLE 1 HERE]

3.1 Identification

The optimal experiment to test the causal impact of parental wealth on offspring achievements would be a random endowment of wealth to parents. The non-random distribution of bequests, which correlates with parental wealth and parental education itself, challenges the identification strategy. To alleviate concerns of clean identification, I match identified bequested families with otherwise similar families. More technically, I use coarsened exact matching as introduced by Iacus et.al (2011, 2012).

[20] Data on house prices are from the Danish register for property sales, also made available by Statistics Denmark.

I match the sample of bequested families to non-bequested families with children aged below 14. The coarsened exact matching is done on; (i) the age in years of the child at grandparent death, (ii) ventiles of parental pre-inheritance wealth and (iii) deciles of parental pre-inheritance income. Finally, since the probability of receiving an inheritance depends on the number of living grandparents, I also match on the number of remaining grandparents prior to the death of the grandparent.

Within these matching strata, I identify the nearest neighbor defined by the difference between the treated and the untreated in total potential inheritance from all living grandparents in the year before a grandparent dies. Potential inheritance is the wealth of each grandparent divided by this grandparent's number of living offspring. The nearest neighbor matching ensures that the treated families are matched to families with similarly expected inheritance so that only the timing of the transmission of estates differ.[21] I am able to find a matching control for 131,670 (99,9 percent) of treated children. Appendix A examines the robustness of the main results to variations in the coarse matching.

To make sure that any differences in outcomes are not due to imbalances from the matching, coming from the coarsening of the matching strata, or due to imbalances arising from excluding important observables as matching parameters (such as parent education), I further control for more granular background characteristics in a regression in the form of

$$Y_i = \beta_0 + \beta_G G_i + \beta_T B_i + \beta_{TG} G_i B_i + \beta_X X_i + \varepsilon_i \tag{1}$$

where Y_i is the outcome variable (e.g. ninth grade average, high school enrollment, potential investment) and G_i is a vector of match group indicators. B_i is a dummy indicating the group of children whose parents inherit, and X_i is the vector of controls. Controls include year fixed effects, child gender, logs of parent's pre-inheritance income, net wealth, and net debt, log of potential inheritance, and parent's highest achieved education (grouped by *no high school*, *high school*, *college*, and *master*). i is the individual child. When Y_i is continuous

[21] Choosing exact matching parameters include a trade-off: the more granular strata I choose, the worse is the nearest neighbor match on potential inheritance. And the fewer beneficiaries I will be able to match.

(like ninth grade grades), (1) is estimated using OLS and when Y_i is binary (like high school enrollment), (1) is estimated using a probit regression.

$Group_i$ splits the sample by the size of inheritance, such that *Group 1* include families inheriting less than 0.5M Danish kroner and their matched controls. *Group 2* include families inheriting 0.5M-1M and their matched controls, *Group 3* inherit 1M-1.5M, *Group 4* 1.5M-2M and *Group 5* more than 2M DKK. By including match group dummies I control for underlying differences between high-inheritance groups and low-inheritance groups. By including interaction between B_i and match groups I allow for match groups to react differently to the wealth shock. Since the baseline is *Group 1*, the coefficient on B_i shows treatment effect for the lowest inheritance group, but is also a measure of the adverse effect of losing a grandparent.

Any difference in outcome between beneficiaries and their controls is a aggregate of two effects: 1) the effect of a wealth shock from the inheritance, and 2) the adverse effect of losing a grandparent. Grandparents may provide care and nurture, but also logistical and financial support for both parents and children, which all potentially impacts child learning.[22] I separate the effect of inheriting by bequest size and assign any parallel shift in outcome curves to losing a grandparent, since the effect will be present independently of inheritance size. Effects that increase with inheritance size I interpret as a wealth effect. Appendix A confirms this approach by performing a robustness check that matches beneficiaries to families who lose a grandparent without inheriting, thereby eliminating 2).

Table 2 presents basic descriptive statistics of the treated children and the control group in the year before grandparent death, along with a balance test. It shows that the match performs well in terms of gender, parental income and wealth, and potential inheritance. There are statistically significant differences in parent's age and education, although they are economically small. Parents are about one and a half years older among beneficiaries and they have on average about two and a half months more education.

[22]To avoid the adverse effect of losing a grandparent, an optimal robustness check would be to study inheritance from childless uncles and aunts, but Danish register data does not allow me to link parents to their uncle and aunts. In order to do that, I would need the link between grandparents and their parents, which for most cases does not exists.

[TABLE 2 HERE]

To verify that I have successfully identified families that inherit and families that do not, Figure 1 plots wealth of the beneficiaries and the controls before and after the death of grandparent or the matching year. The figure clearly shows that families inheriting more than 0.5M DKK experience a permanent wealth shock and that the control group does not. However, families inheriting less than 0.5M DKK only have a small and temporary wealth shock, which is not surprising since, as seen in Figure A.2, the majority inherit very small amounts or nothing. Figure 1 also shows that high-inheritance families have higher pre-inheritance wealth than low-inheritance families, emphasizing the importance of matching to similar families.

[FIGURE 1 HERE]

Having established that the beneficiaries actually do experience a long lasting wealth shock, next step is to study how it impact educational outcomes of the children and how parents invest the bequest in the family.

4 Results

Table 3 shows the results from regressions of the the econometric specification in (1). Column 1 examines the effect of wealth on children's grade average, column 2 examines the effect on high school enrollment, column 3 the effect on high school dropout rate, and column 4 the effect on on university enrollment.

Although coefficients are small, children from high-inheritance families and their matched controls, as expected, on average obtain higher grades than the low-inheritance group. *Group 2* on average obtain 0.042 grade units (0.02 standard deviations) higher than the low-inheritance group, and *Group 3* to *Group 5* on average obtain 0.072-0.095 grade units (0.03-0.04 standard deviations) higher than the low-inheritance match group.

The effect of bequests on grades is low.[23] Beneficiaries, on average, show a negative

[23]In line with Cesarini et al.(2016), which for Sweden finds small, negative, and statistically insignificant effects of lottery gains on ninth grade GPA.

effect on grades of 0.085-grade units (0.03 standard deviations), which reflects the adverse impact of losing a grandparent. Increasing the size of the inheritance does not significantly alleviate the effect, implying no wealth effect on grades.

The same pattern is observable for high school enrollment (column 2), high school dropout (column 3), and university enrollment (column 4). To show the magnitude in columns 2 through 4, Figure 2 shows the corollary marginal effects. Children from high-inheritance families and their matched control are, on average, more likely to enter high school and university but are not significantly different from *Group 1* in dropping out from high school. Losing a grandparent hurts both high school and university enrollment, but do not affect dropping out of high school. The effects of receiving larger bequests are no different from inheriting smaller bequests, implying no casual effect on educational accomplishments as measured here.

[TABLE 3 HERE]

Figure 2 shows marginal effects for each treated group, holding other controls at their means. Bequests by the loss of a grandparent has a statistically significant negative (but small) impact on grades, illustrated by the parallel shift in profiles of the beneficiaries relative to the control, but the size of the inheritance do not level out the difference, showing no impact of the wealth shock. The same is true for high school enrollment, while the high school drop out rate shows no significant difference between beneficiaries and control. University enrollment shows weak signs of a wealth effect since beneficiaries in the low-inheritance group are less likely than the untreated to enter university, while the difference is alleviated for higher inheritance groups.

[FIGURE 2 HERE]

The little effect of wealth shown in Figure 2 begs the question of whether inheritance size results are muted by pre-inheritance parental wealth. If larger inheritances are primarily allocated to already wealthy parents, parents who inherit may already have optimized the educational conditions for child education, and the effect would be muted, even for large inheritances. To investigate this, the first column in Figure 3 split effect on grades by parent pre-inheritance wealth. If any effect exists, one would expect that the effect would be largest for families with low wealth who inherit large amounts. Although differences are small, panel (a) do show that low-income families inheriting small amounts experience a negative effect on grades, but as inheritance size increases, the difference between beneficiaries and controls goes to zero. Top wealth families show no impact of inheriting irrespective of the amount inherited (panel (e)). The middle 50 percent of the wealth distribution shows a negative effect of inheritance, with the difference increasing with inheritance size (panel (c)). Appendix figures A.3, A.4, and A.5 shows education by pre-inheritance wealth and find no effect of even large bequests on outcomes for either wealth group.

One potential concern is that measured net wealth does not reflect parent's actual resources in the time when they have young children.[24] Since children are costly, parents with young children may consume a large share of their income, irrespective of income size. Relative to low-income families, high-income families have higher creditworthiness, allowing them to borrow more for consumption, which results in smaller or even negative net wealth.[25] Looking at pre-inheritance income instead, the second column in Figure 3, plots the marginal effect of inheritance on grades by pre-inheritance income. Low income families show a small negative effect of inheritance on grades of children, which is only expanded by larger bequests, although neutralized for the largest bequests. High income families show no effect of inheritance for any size of inheritance, while the middle income families show no effect except for a negative effect of a large inheritance. Appendix figures A.3, A.4, and A.5 shows effects on further education by pre-inheritance income and find no effect of even large bequests for either income group.

[FIGURE 3 HERE]

For young families, income may not be a good proxy for family resources since the parents are at the beginning of their careers, and their financial decision making should be based

[24]This is also pointed out by Cesarini et al. (2016)

[25]For instance, a family with a steady income stream but zero net wealth can take out a consumer loan to finance a car. In that case their registered net wealth will be negative, since the value of the car is not included in the wealth measure. The mechanic measurement of net wealth also explains why the the coefficients to both positive and negative wealth is above (below) zero in Table 3, Column 1 and 4 (3).

on expected future income. Figure 4 examines this concern by splitting the grade plots by parental education to proxy for income expectations. Grade levels are highly correlated with parent's education, but neither the loss of a grandparent nor larger wealth shock affect grades. These results suggest that even the small observed differences, may be a consequence of mismatched education levels in the matched groups.[26]

To summarize, a positive wealth shock to parents in the shape of a bequest does not seem to positively impact educational outcomes of children.

[FIGURE 4 HERE]

4.1 Parents' investments

If wealth shocks give parents the ability to invest in their children's prospect, why is it not observed? Either parents are able, but not willing, to invest in their offspring, or else children are unable to harvest the payoff of the investment. That is, why does the inherited wealth not end up in the educational achievement of children?

I examine several different instruments of investments, which requires financial flexibility and which could potentially impact children's education. First, I study the moving behavior of the household in which the child lives. Moving may have an impact if it gives access to a higher quality school, either by school resources or better networks. Figure 5 shows moving propensity within the first three years following a bequest. While beneficiaries of less than 1.5M DKK are not more likely to move than their matched controls, beneficiaries of more than 1.5M DKK are in fact 3 to 7 percentage points more likely to move to a different address than the control group. Panel (b) and (c) of Figure 5 show that while the majority of movers move to a separate shire, most of them do not change the municipality, letting the children remain in the same school. That is, even if the family move, the impact on child education is minor.

[FIGURE 5 HERE]

To determine what drives the moving decision Figure 6 shows changes in neighborhood

[26] Appendix A examines the robustness of results to matching on parent education and find similar results to above.

characteristics for families moving address. Panel (a) to (c) is restricted to families moving to a different shire and show changes in local (shire-specific) mean income, square meter price, and crime rates, while panel (d) focuses on the individual home and shows the three-year change in house size for all families who move. Moving shire does not result in any significant changes in neighborhood characteristics, although beneficiaries who inherit more than 1.5M DKK are more likely to move to higher-crime neighborhoods than their matched counterparts, probably reflecting moves to more urban, more expensive, areas. In addition, beneficiaries of more than 0.5M DKK who move address, upgrade their house size more than their matched controls, but the differences is only statistically significant for beneficiaries of more than 2M.

Taken together, Figure 5 and Figure 6 show that parents who inherit large amounts react by moving, but they are mostly motivated by more space and not by better neighborhoods or schools.

[FIGURE 6 HERE]

To examine whether the parents adjust their work hours or work effort to spend more time at home, Figure 7 study the three-year income growth of parents. Although previous studies (Imbens et al., 2001, Cesarini et al., 2017) have shown wealth shocks to (modestly) impact labor supply negatively (with the same effect for men and women), parents do not seem to adjust working hours or effort. While both parent's income growth is lower among beneficiaries than controls (probably reflecting that parent beneficiaries are a bit older), both the mother's and the father's income growth is unaffected by the size of the inheritance.

Relatedly, extra wealth can improve the environment at home, reducing stress and making it easier for children to harvest benefits from education. Figure 7 shows effects on divorce of married parents and reveals a statistically significant, but economic insignificant increase in divorce rates among beneficiaries inheriting small amounts.[27] The effect is reversed for parents inheriting between 0.5M and 1.5M with beneficiaries being 0.8-1.2 percentage points

[27] Groups of beneficiaries and their controls are balanced in terms of marriage propensity among parents for groups 2 to 5. In the group who inherit less than 0.5M, 66 percent of beneficiaries are married, while 69 percent of the control group are married, and this difference is statistically significant.

less likely to get divorced, corresponding to a decrease of 12-18 percent. For larger size bequest the difference is statistically insignificant.

[FIGURE 7 HERE]

Figure 8 shows the response of youth work by age group. A potential investment in child education could be larger pocket money allowances to ensure that the child spends time on school instead of taking up a youth job. However, Figure 8 reveals no meaningful differences between beneficiaries and controls in the propensity to have a youth job for any age group.

[FIGURE 8 HERE]

Lastly, a wealth shock may be consumed or invested in "leisure consumption" by the parents. Figure 9 show the three-year change in car wealth and value of owned holiday home(s). Beneficiaries of more than 0.5M DKK increase car consumption significantly more than the control group, with beneficiaries of 0.5-1M DKK on average upgrading their cars by 5K DKK more than the control group and beneficiaries of more than 2M DKK upgrading by more than 26K DKK extra relative to the controls. The same pattern shows for holiday homes, with beneficiaries of more than 0.5M DKK buying holiday homes of 23K-154K DKK more than their matched controls.

[FIGURE 9 HERE]

Summing up, parents seem to respond to wealth shocks by moving to a bigger home, buying a (bigger) car, buying a holiday home, and to some degree, getting divorced less frequently. While bigger homes and less divorces could potentially improve child learning, it does not show in education effects, likely because parents do not invest in ways that could impact child education, such as moving school or reducing parent and children work.

5 Conclusion

This study uses bequests from grandparents as a casual shock to family wealth and shows that the effect of parental financial ability on child educational outcomes is limited. The study matches children of parents who inherit while the child is young to children whose parents do not inherit but are otherwise similar. In line with previous research, I find no significant effect of bequests on child ninth-grade GPA, high school enrollment, high school drop out rate, and university enrollment.

In an attempt to explain the lacking effect of a wealth shock on education, the study then turns to examine parent's investments following a bequest. Parents do invest the bequest, but only to a minor degree in initiatives that could potentially impact education. Bequests are instead invested in larger homes, cars, and holiday homes, but not in better neighborhoods, better schools, or family time. In a public finance perspective, these results suggest that in a setting with universal education, investing in public pre-school and school quality are more efficient than policies that financially support parents.

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Figure 1
Wealth of beneficiaries and controls

This figure plots mean net wealth of the 131,670 matched parent pairs in the time around inheritance, by size of inheritance. Amounts are in 1000s 2015 DKK. Bands show 95 percent confidence intervals.

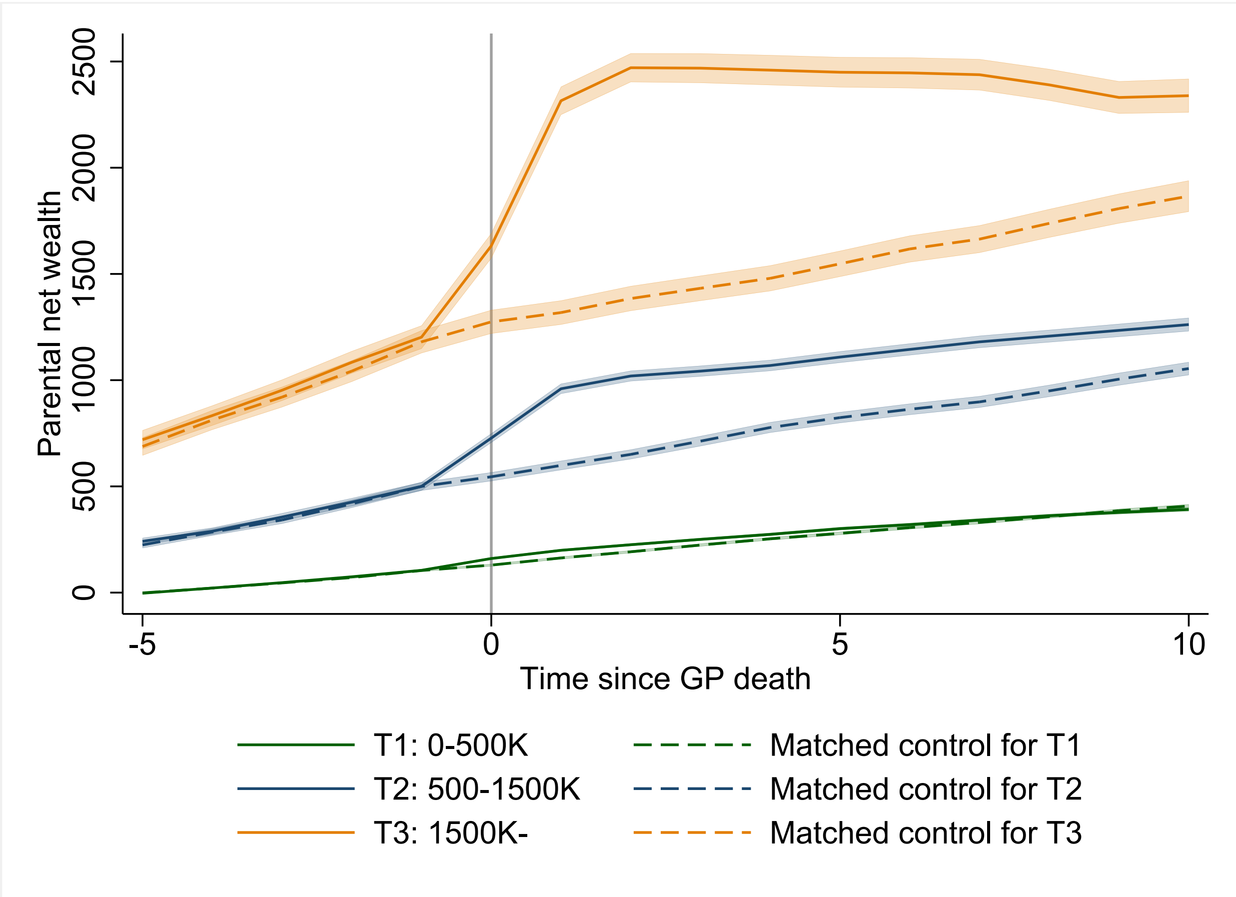
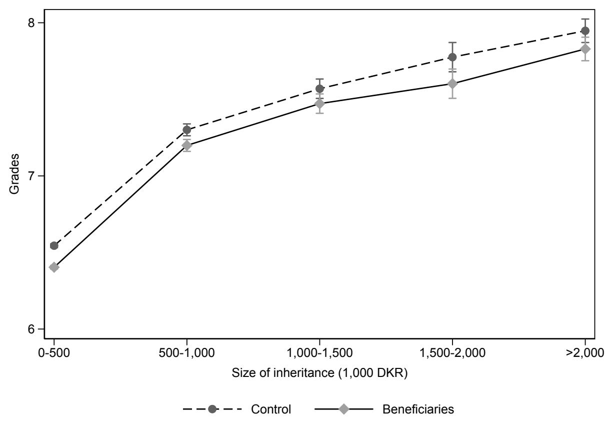


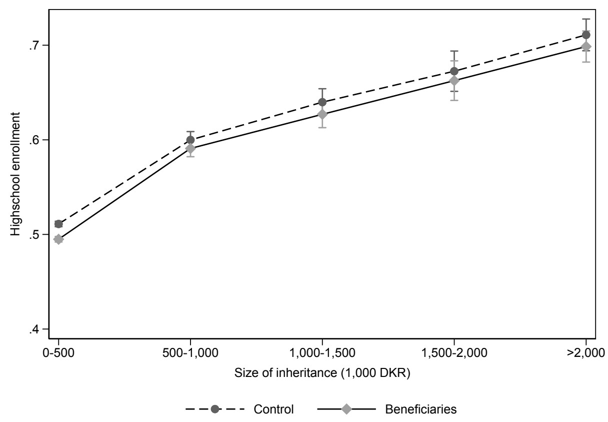
Figure 2
Marginal effects

This figure shows marginal effects from estimation of (1) by inheritance size and group, holding other controls at their means. Panel (a) shows effects on ninth grade grades and is based on an OLS regression of (1). Panel (b), (c) and (d) are all based on probit regressions of (1) and show effects on high school enrollment, high shool drop out rate, and university enrollment, respectively. Panel (b) has all ninth grade graduates who graduated before 2018, panel (c) all ninth grade graduates who enrolled in high school, and panel (d) all high school graduates. Vertical lines reflect the 95 percent confidence interval.

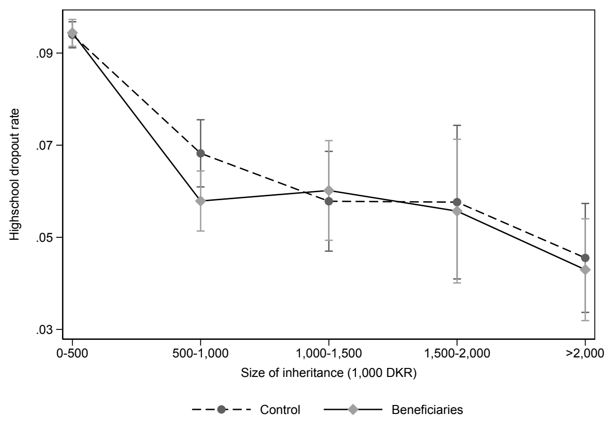
(a) Grades



(b) High school enrollment



(c) High school dropout rate



(d) University enrollment

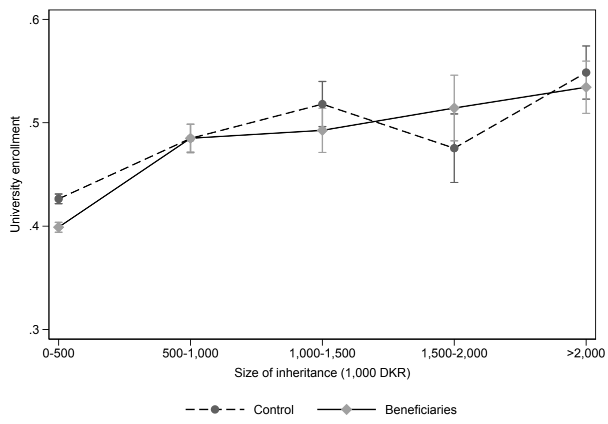
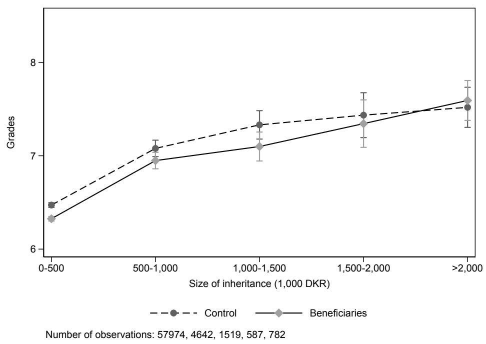


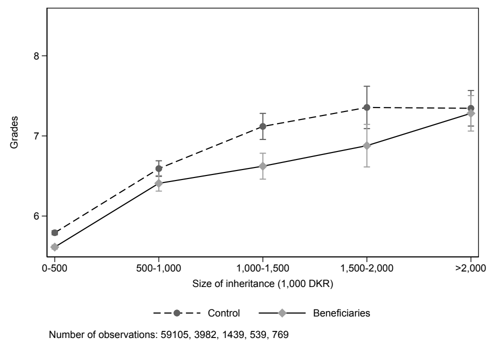
Figure 3
Marginal effects on grades, by pre-inheritance wealth and income

This figure shows marginal effects on grades from estimation of (1) by inheritance size and quartiles of pre-inheritance wealth and income of parents, holding other controls at their means. Vertical lines reflect the 95 percent confidence interval.

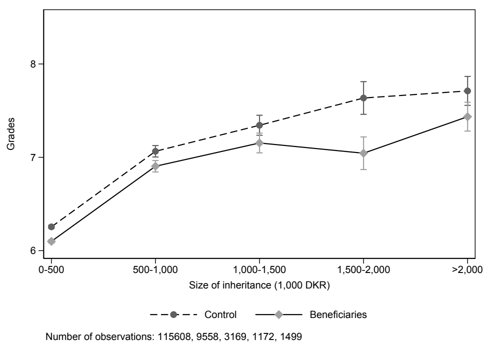
(a) 1st wealth quartile



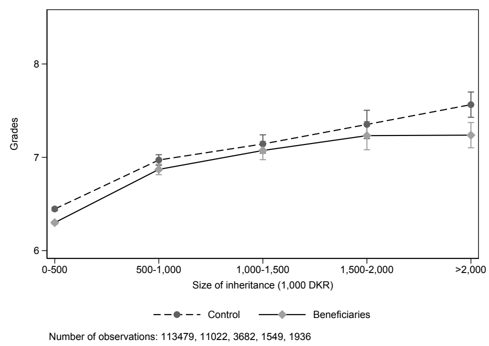
(b) 1st income quartile



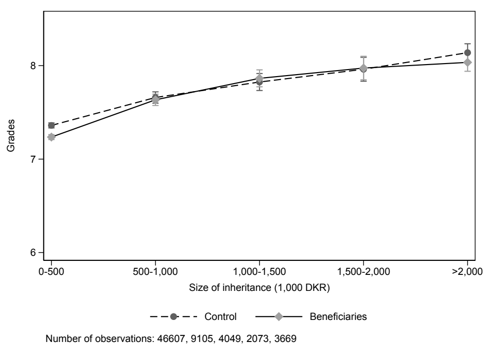
(c) 2nd and 3rd wealth quartile



(d) 2nd and 3rd income quartile



(e) 4th wealth quartile



(f) 4th income quartile

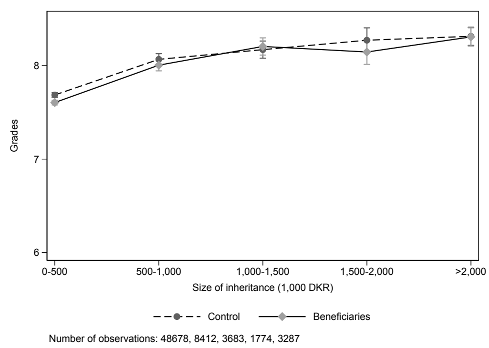
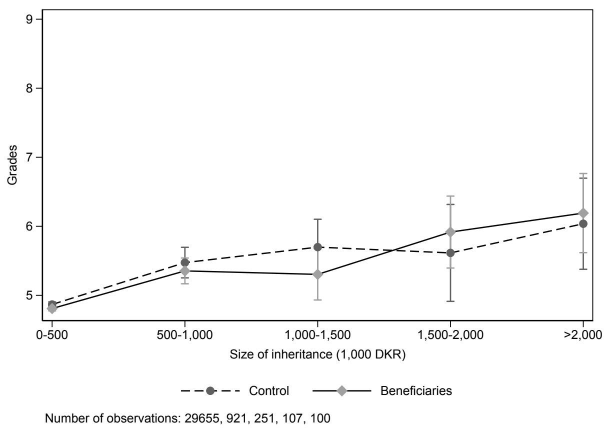


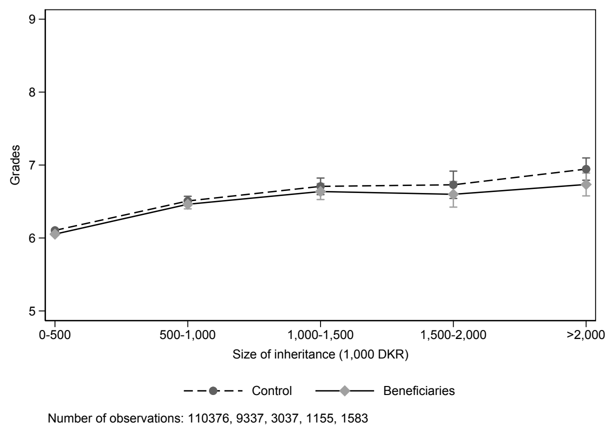
Figure 4
Marginal effects on grades, by parental education

This figure shows marginal effects on grades from estimation of (1) by inheritance size and parent education, holding other controls at their means. Vertical lines reflect the 95 percent confidence interval.

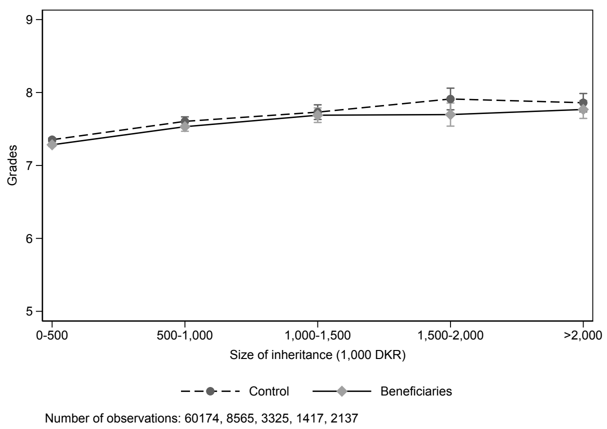
(a) No high school



(b) High school



(c) College



(d) Master

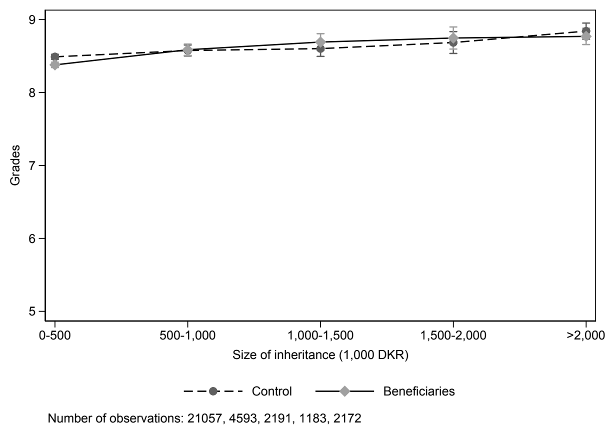
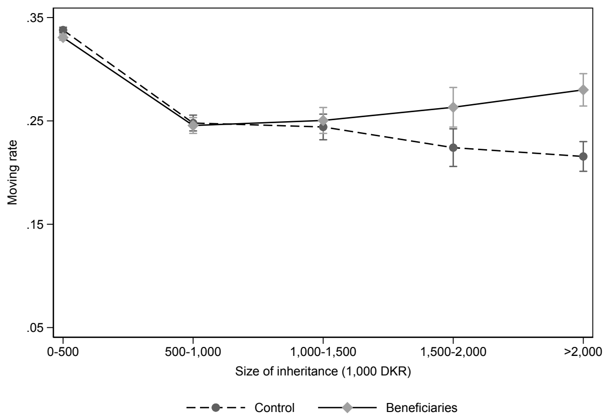


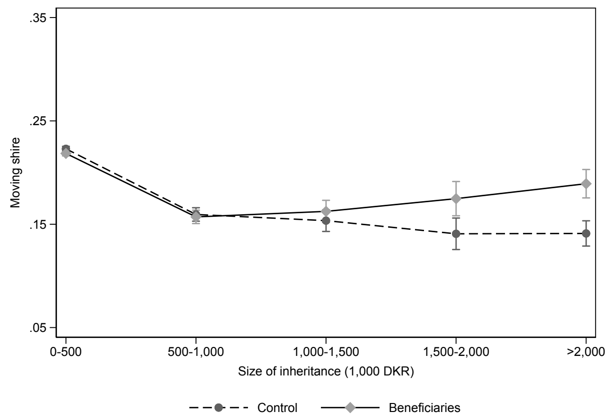
Figure 5
Moving

This figure shows marginal changes in housing by match group, holding other controls at their means. It is based on probit regressions of (1). Panel (a) shows moving propensity within three years from inheriting. Panel (b) shows propensity to move to a different shire within three years, panel (c) shows propensity to move to another municipality within three years, and panel (d) shows propensity to change school within three years from inheriting for children at least five years old at inheritance. Vertical lines reflect the 95 percent confidence interval.

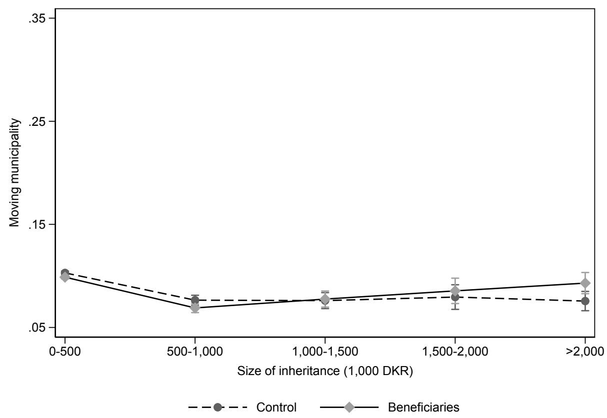
(a) Moving



(b) Moving shire



(c) Moving municipality



(d) Moving school

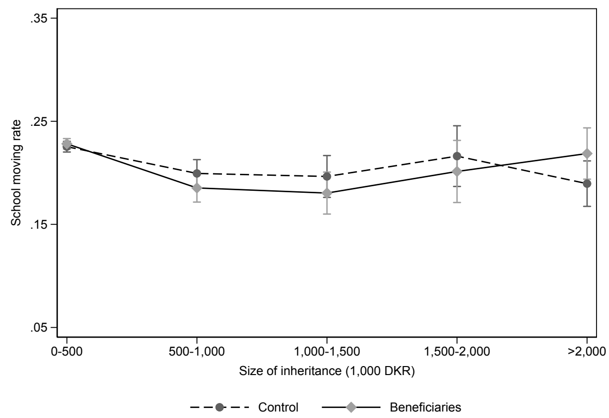
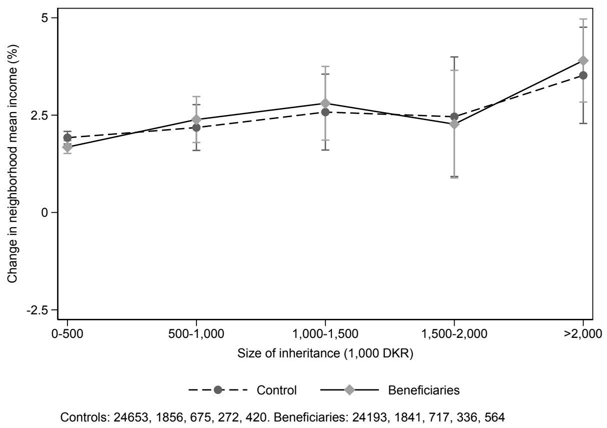


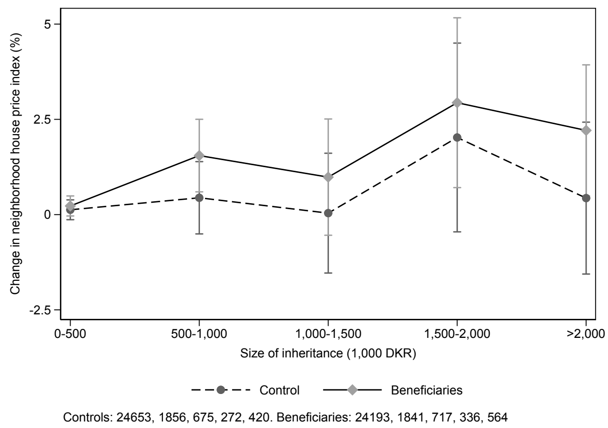
Figure 6
Change in home size and neighborhood

This figure shows marginal changes in housing by match group, holding other controls at their means. It is based on probit regressions of (1). Panel (a) show the percentage difference in mean income between the old and new shire, for households moving to a new shire within three years. Panel (b) show the percentage difference in average square meter prices between the old and new shire, for households moving to a new shire within three years. Panel (c) show the change in non-traffic related convictions per 1,000 inhabitants between the old and new shire, for households moving to a new shire within three years. Panel (d) shows the percentage three-year change in home size for all movers. Vertical lines reflect the 95 percent confidence interval.

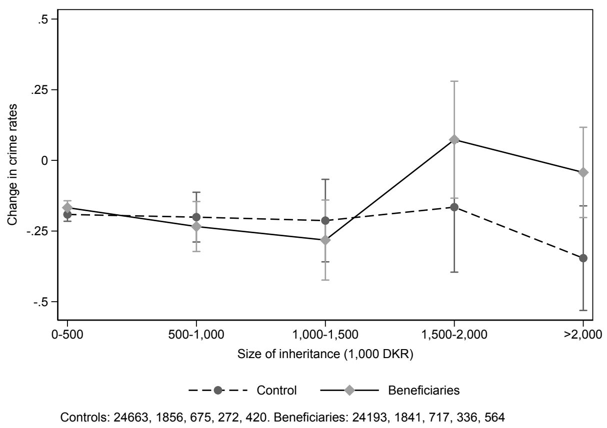
(a) Local mean income, moving shire



(b) Local house prices, moving shire



(c) Local crime rates, moving shire



(d) House size, movers

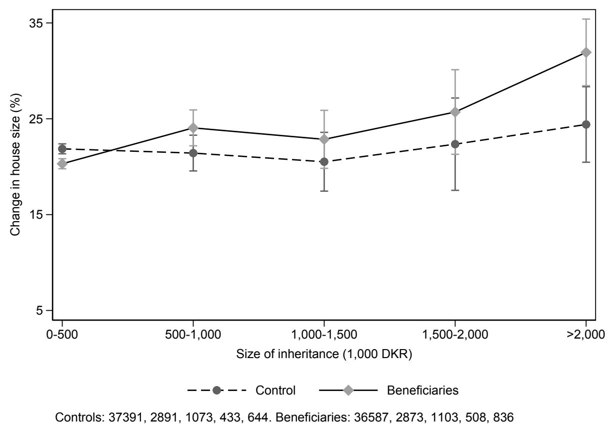
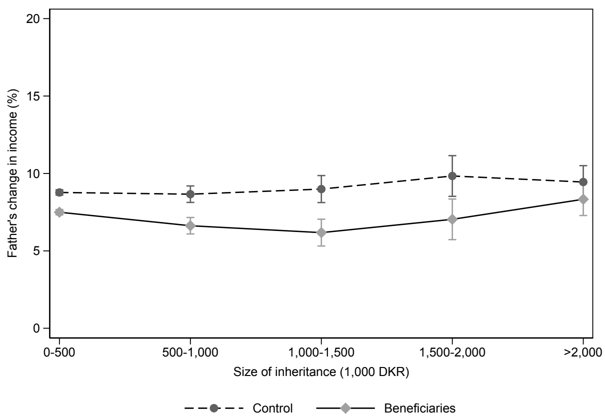


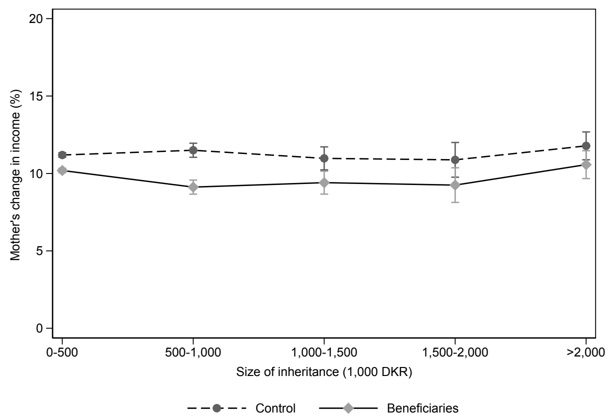
Figure 7
Family investments

This figure shows marginal effects by match group, holding other controls at their means. Panel (a) shows effects on the father's income growth from t-1 to t+2. Panel (b) shows effects on the mother's income growth from t-1 to t+2. Panel (c) shows effects on propensity for at least one parent to get divorced within three years. Panel (a) and (b) are based on an OLS regression of (1), while panel (c) is a probit. Vertical lines reflect the 95 percent confidence interval.

(a) Father's change in income



(b) Mother's change in income



(c) Divorce rate

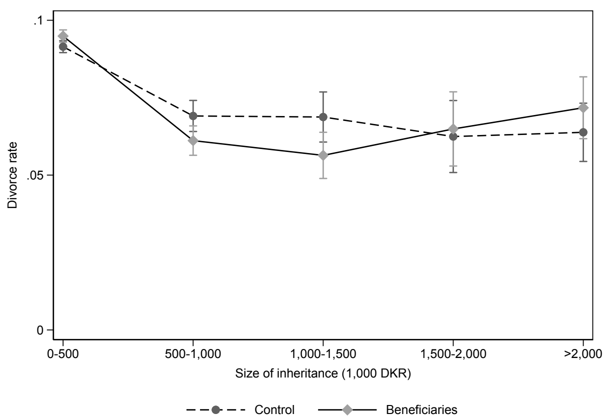
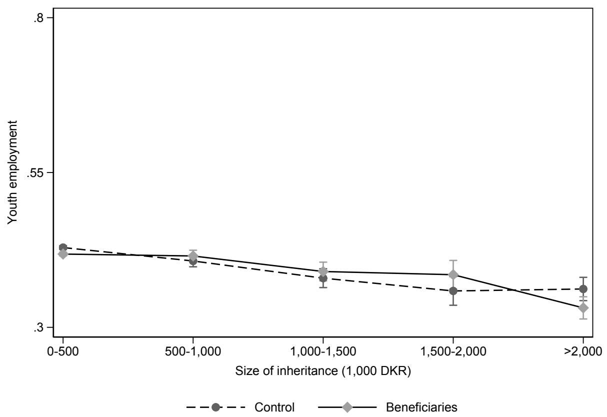


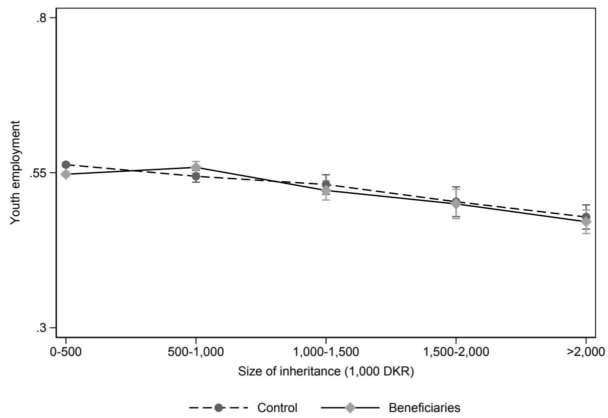
Figure 8
Youth work

This figure shows marginal effects on the propensity to have a youth job by match group and child age, holding other controls at their means. It is based on probit regressions of (1). Vertical lines reflect the 95 percent confidence interval.

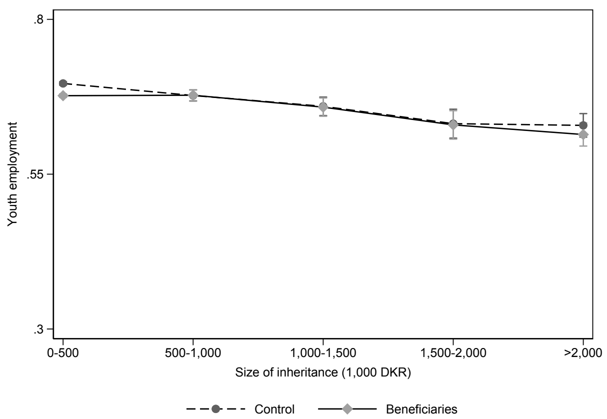
(a) 13 years old



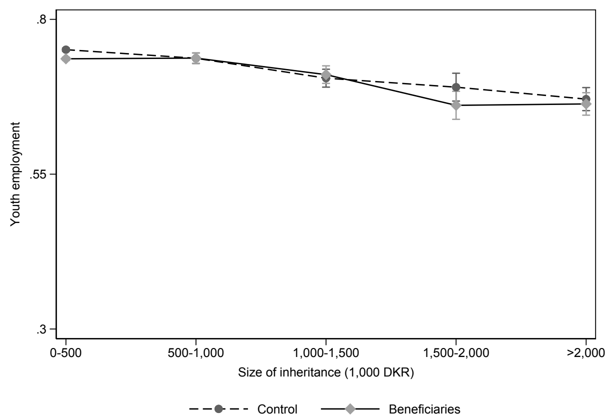
(b) 14 years old



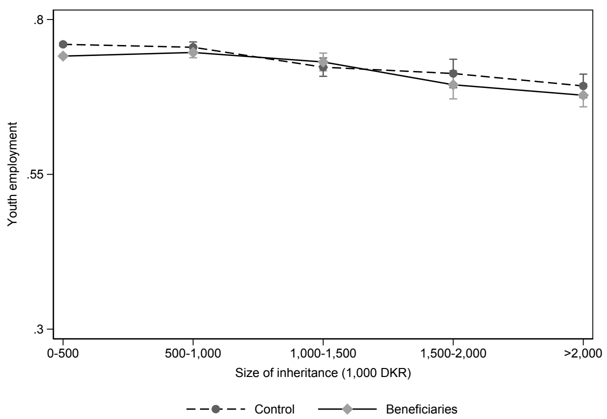
(c) 15 years old



(d) 16 years old



(e) 17 years old



(f) 18 years old

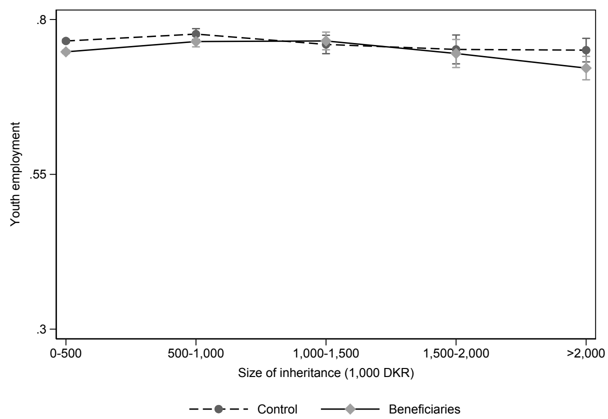
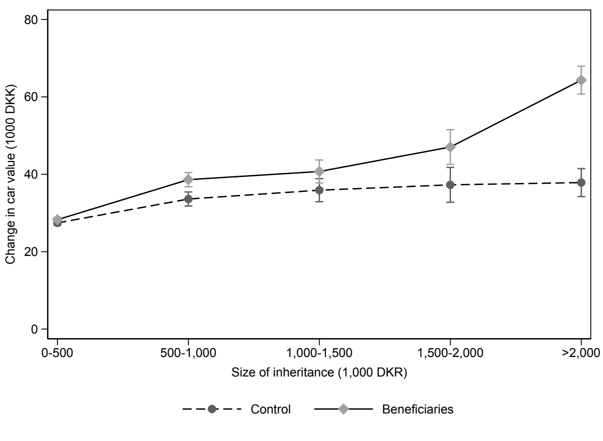


Figure 9
Consumption

This figure shows marginal effects by match group, holding other controls at their means. It is based on OLS regressions of (1). Panel (a) shows effects on the change in family total car value from t-1 to t+2, for years 2004-2019. Panel (b) shows effects on change in parent total value of owned holiday homes from t-1 to t+2. Vertical lines reflect the 95 percent confidence interval.

(a) Cars



(b) Holiday homes

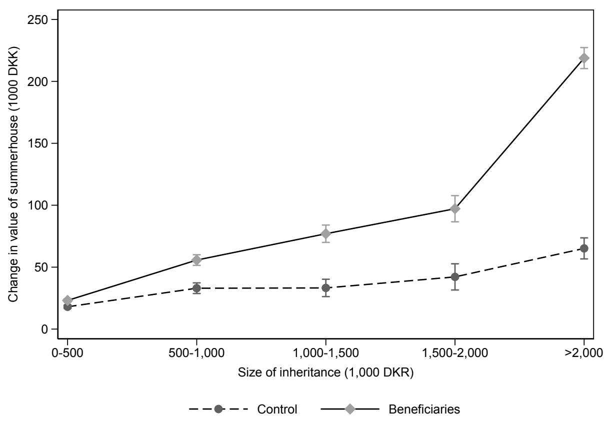


Table 1
Descriptive statistics

This table shows means and standard deviations describing all ninth grade graduates from 2002 to 2019, at age 0 (Column 1 to 3) and year of graduation (Column 4 to 6). Parental education is the length (in years) of the highest achieved education among parents. Parental wealth and income are totals of the mother's and the father's wealth and income, respectively. Potential inheritance is the total of each grandparent's wealth split by each their number of children. Amounts are in 1000s 2015 DKK. Column 1 and 4 have all graduates. Column 2 and 5 have graduates whose family have inherited from a unmarried deceased grandparent before the graduate turned 10 years old. Column 3 and 6 have all graduates who did not loose a grandparent before turning 14 years old (potential controls). Mismatch in number observations between Column 1 to 3 and Column 4 to 6 are due to a imbalanced data set, with some graduates not being in Denmark at age 0.

	At age 0			At graduation		
	(1)	(2)	(3)	(4)	(5)	(6)
	All	Beneficiaries	Pot. controls	All	Beneficiaries	Pot. controls
	mean/sd	mean/sd	mean/sd	mean/sd	mean/sd	mean/sd
Female (child)	0.50	0.50	0.50	0.50	0.50	0.50
	0.50	0.50	0.50	0.50	0.50	0.50
Child age	0.00	0.00	0.00	15.15	15.15	15.17
	0.00	0.00	0.00	0.45	0.42	0.48
Mother's age	29.25	30.16	28.66	44.31	45.32	43.66
	4.78	4.90	4.87	4.81	4.89	4.92
Father's age	32.00	33.00	31.54	47.04	48.10	46.57
	5.71	5.74	6.03	5.65	5.68	5.95
Parental education length	14.58	14.44	14.52	14.96	14.85	14.88
	2.18	2.19	2.25	2.30	2.19	2.46
Parental income	591.49	610.30	564.46	801.96	805.97	770.21
	239.09	237.53	239.77	363.85	345.57	371.51
Parental wealth	6.13	5.17	-0.23	531.58	566.83	442.22
	678.78	695.37	643.57	1529.41	1584.39	1435.17
Living grandparents	3.07	3.20	2.83	2.27	1.56	2.55
	1.20	0.85	1.45	1.30	0.93	1.55
Potential inheritance	650.79	642.96	573.73	797.35	494.13	843.18
	848.44	838.74	815.04	1049.23	810.91	1100.43
Grades				6.64	6.57	6.55
				2.45	2.45	2.48
Observations	977109	128032	448415	1058131	132321	510876

Table 2
Balance test

This table compares characteristics of all matched beneficiaries to the matched control group from the year before grandparent deaths. Parental education is the length (in years) of the highest achieved education among parents. Parental wealth and income are totals of the mother's and the father's wealth and income, respectively. Potential inheritance is the total of each grandparent's wealth split by each their number of children. Amounts are in 1000s 2015 DKK. ***, **, and * indicate statistical significance at the 0.1, 1, and 5 percentage levels.

	(1)		(2)		(3)	
	Beneficiaries		Control		Difference	
	mean	sd	mean	sd	b	p
Female (child)	0.50	0.50	0.50	0.50	0.00	(0.77)
Child age	5.05	2.82	5.05	2.82	0.00	(1.00)
Mother's age	35.24	5.65	33.76	5.52	1.49***	(0.00)
Father's age	38.04	6.34	36.41	6.46	1.63***	(0.00)
Parental education length (years)	14.62	2.21	14.80	2.19	-0.19***	(0.00)
Parental income	700.25	283.25	700.63	284.88	-0.38	(0.73)
Parental wealth	194.37	1045.19	192.68	1038.37	1.70	(0.68)
Living grandparents	2.95	0.87	2.95	0.87	0.00	(1.00)
Potential inheritance	738.03	940.45	737.01	937.68	1.02	(0.78)
Observations	131670		131670		263340	

Table 3

Bequest effects

The table shows the results from OLS or probit regressions of the grade average, high school enrollment, high school dropout rate and university enrollment on beneficiary status and group indicators as well as a number of controls. *Beneficiaries* indicates children whose parents inherit before the child has turned 10. *Group 2* indicates treated who inherited between 0.5M DKK and 1M DKK and their matched controls. *Group 3* indicates treated who inherited 1-1.5M DKK and their matched controls. *Group 4* indicates treated who inherited 1.5-2M DKK and their matched controls. *Group 5* indicates treated who inherited more than 2M DKK and their matched controls. Column 1 shows results from a OLS regression of grades and has all ninth grade graduates. Column 2 to 4 are probit regressions on high school enrollment, high school dropout rate, and university enrollment, respectively. Columns 2 has all ninth grade graduates who graduated before 2018. Column 3 has all ninth grade graduates who enrolled in high school. Columns 4 has all high school graduates. Standard errors are in parentheses and ***, **, and * indicate statistical significance at the 0.1, 1, and 5 percentage levels, respectively .

	(1) Grades (OLS)	(2) HS enrollment (probit)	(3) HS dropout (probit)	(4) UNI enrollment (Probit)
main				
Group 2	0.042**	0.043***	0.027	0.024
	(0.021)	(0.014)	(0.031)	(0.021)
Group 3	0.083***	0.087***	-0.023	0.075**
	(0.032)	(0.023)	(0.052)	(0.033)
Group 4	0.095**	0.099***	0.044	-0.031
	(0.048)	(0.035)	(0.080)	(0.048)
Group 5	0.072*	0.172***	-0.032	0.108***
	(0.037)	(0.030)	(0.069)	(0.039)
Beneficiaries	-0.085***	-0.022***	-0.000	-0.038***
	(0.009)	(0.006)	(0.013)	(0.010)
Beneficiaries x Group 2	0.045	0.012	-0.106**	0.040
	(0.029)	(0.019)	(0.044)	(0.029)
Beneficiaries x Group 3	0.050	-0.001	0.040	0.013
	(0.045)	(0.031)	(0.071)	(0.045)
Beneficiaries x Group 4	-0.005	0.033	-0.035	0.109
	(0.066)	(0.049)	(0.111)	(0.067)
Beneficiaries x Group 5	-0.021	-0.019	-0.008	-0.020
	(0.052)	(0.041)	(0.094)	(0.053)
Female (child)	0.603***	0.646***	-0.197***	-0.040***
	(0.008)	(0.006)	(0.012)	(0.009)
Parental income (log)	0.412***	0.121***	-0.121***	0.159***
	(0.012)	(0.008)	(0.016)	(0.013)
Parental net wealth < 0 (log)	0.027***	-0.000	-0.005	0.020***
	(0.003)	(0.002)	(0.005)	(0.004)
Parental net wealth > 0 (log)	0.087***	0.011***	-0.034***	0.038***
	(0.003)	(0.002)	(0.005)	(0.003)
Potential inheritance (log)	0.092***	0.008***	-0.036***	0.013***
	(0.002)	(0.002)	(0.003)	(0.003)
No highshool (parents)	-0.924***	-0.285***	0.254***	-0.137***
	(0.015)	(0.009)	(0.021)	(0.020)
College (parents)	1.045***	0.516***	-0.153***	0.342***
	(0.010)	(0.007)	(0.014)	(0.010)
Master (parents)	1.912***	1.018***	-0.292***	0.727***
	(0.014)	(0.011)	(0.021)	(0.014)
Constant	2.072***	-1.841***	-0.067	-1.971***
	(0.196)	(0.151)	(0.337)	(0.287)
YearFEs	Yes	Yes	Yes	Yes
Observations	263340	233248	93271	89083

Appendix

A Robustness to matching procedure

To make sure that the results are not a consequence of the specific matching choices, I repeat the analysis with the following different matching procedures. In my preparing research, I have matched on numerous other parameter combinations, with different success in quality of match, but all with similar results.

1. **Matching on parental wealth**: Since I am studying the effect of a wealth shock, it is important to match pre-inheritance wealth levels, but in the main matching procedure I only do exact matching on wealth ventiles and let the potential inheritance secure a good match of parents. To fully focus on matching parent wealth, I instead conduct nearest neighbor matching on parental wealth, holding all exact matching parameters fixed. I am able to find a matching control for 99.9 percent (313,683) of beneficiaries.

2. **Matching on parental education**: To make sure that the small difference in parent education in Table 2 does not influence results, I add parent education to the exact matching parameters. Parent's highest acheived education is grouped into "no high school" "high school" "college" and "master". I am able to find a matching control for 98.3 percent (129,578) of beneficiaries.

3. **Matching to other deaths:** Inheritances are wealth shock, but the size and timing is not perfectly random. First, grandparent's health and wealth may be correlated, resulting in wealthier grandparents on average dying later. This impacts who inherit while the children are young and also the size of the inheritance. Second, grandparent's health and wealth are likely to be correleated with parent's wealth and health, meaning that families that inherit large amounts already are better off prior to inheritance than families inheriting smaller amounts. Third, while alive, grandparents may transfer ressources to their children and grandchildren, so the loss of a grandparents may

financially correspond to receiving a wealth shock but losing a cash stream. Last but not least, the death of a grandparent is also a loss of a close relative who provides love and care for the children and potentially helps with babysitting providing the parents some flexibility for their labor force participation. To neutralize the adverse effect of losing a grandparent I match families that inherit to families, who also lose a grandparent to death, but where the deceased is married and thus the settling of the estate is likely to be postponed until the spouse dies or remarries.[28] In all other aspects matching parameters are the same as in the main analysis. I am able to find a matching control for 94.8 percent (93,600) of beneficiaries.

Figure A.6 shows wealth profiles before and after inheritance for beneficiaries and their matched controls for the three different matching procedures. All three match pre-inheritance wealth well, although matching to other deaths is not as good as the first two, when looking at wealth up to five years before inheriting. While matching on parental wealth and education (Table A.1 and Table A.2) find controls that matches well on all parameters, matching to other deaths (Table A.3) results in a control group with on average 88 thousands DKK smaller potential inheritance. As I add restrictions to the exact matching, finding close neighbors in nearest neighbor matching of course gets harder, explaining why the match of potential inheritance performs worse.

Figure A.7 shows marginal effects on grades by matching method. While there in panel (a) and (b) seems to be a negative effect of inheriting without any size effect, there is no difference between beneficiaries and controls in panel (c). It confirms that the negative effect in panel (a) and (b) most likely are results of losing a grandparent and when the beneficiaries are matched to controls that also loses a grandparent, the effect is gone. Thus, all three methods verify the conclusion from the main matching approach: there is no positive effect of a wealth shock, only a negative effect of losing a grandparent.

[28]I require that the control group do not inherit from a grandparent before the age of 14.

B Additional Tables and Figures

Figure A.1
Grade distribution

The figure shows the distribution of average Danish, math, and English grades among all Danish ninth graders, graduating from 2002 to 2019

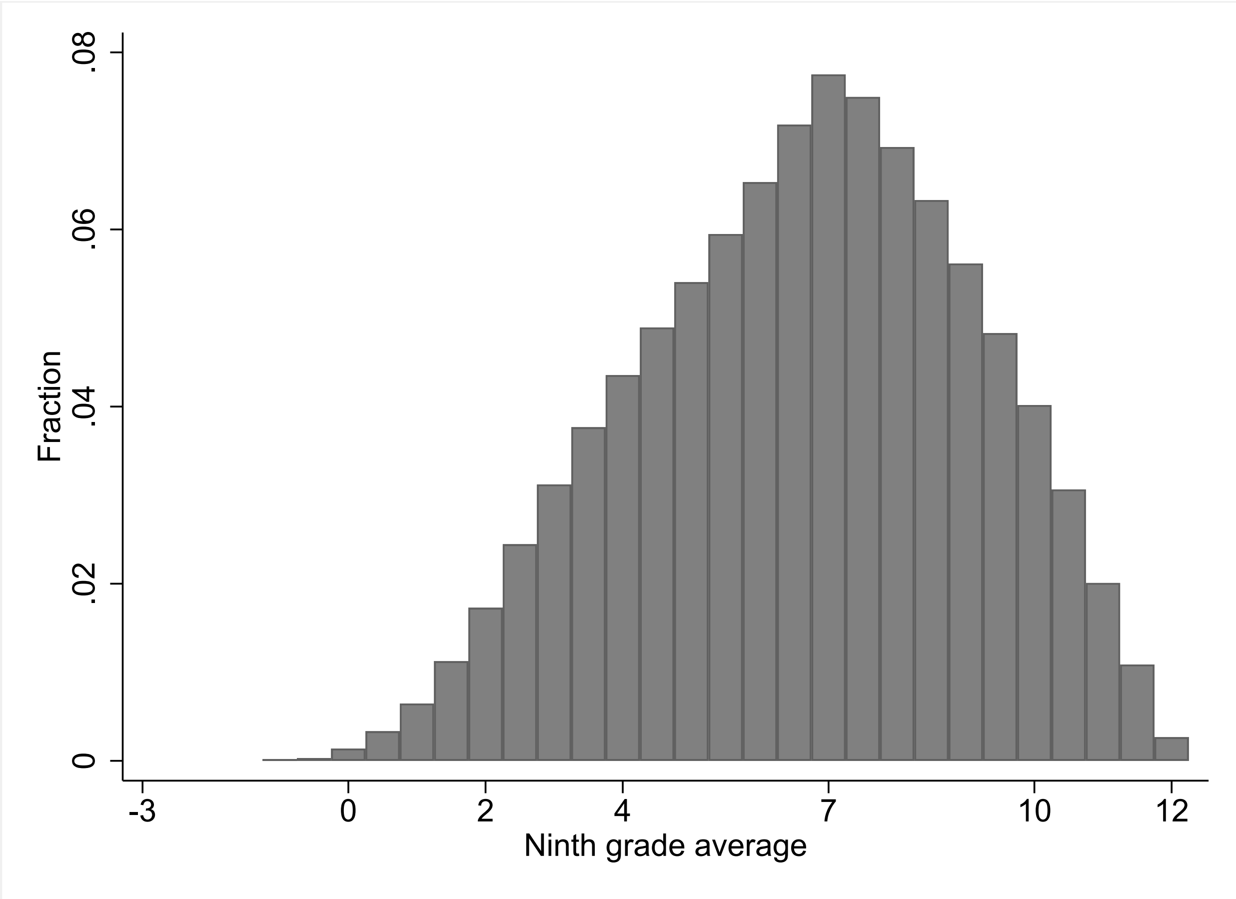


Figure A.2
Inheritance distribution

The figure shows the distribution of inheritance (winsorized at 1 percent in both ends).

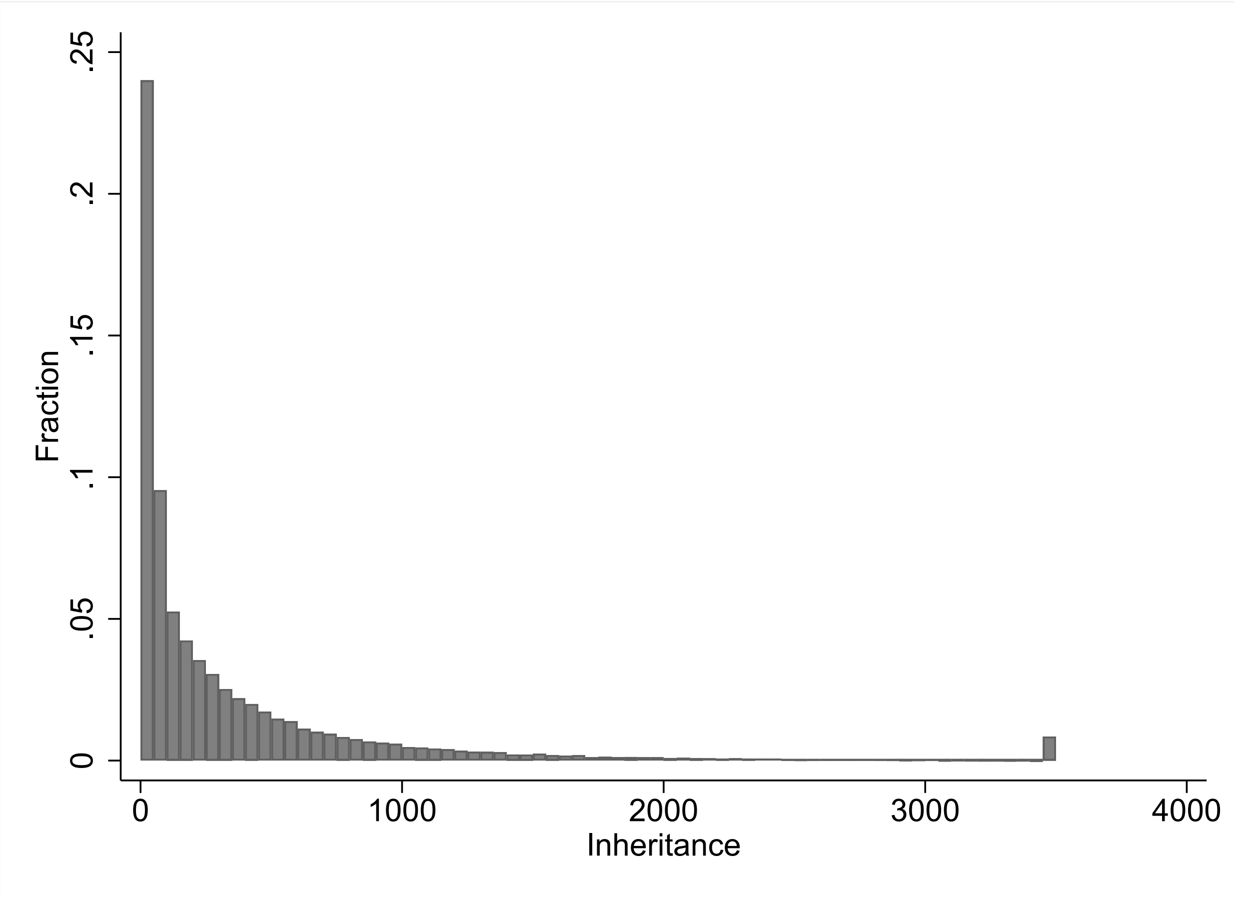
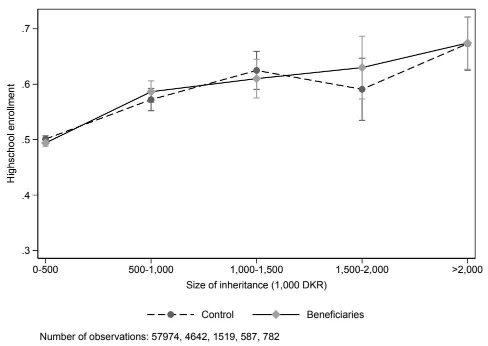


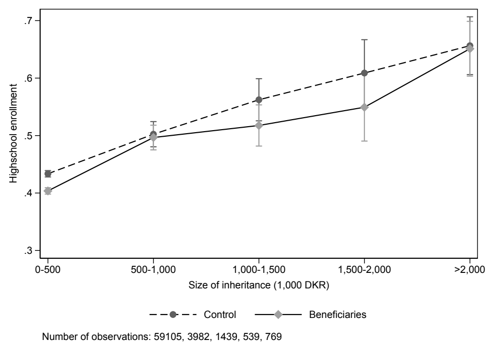
Figure A.3
Marginal effects on high school enrollment, by pre-inheritance wealth and income

This figure shows marginal effects on high school enrollment by inheritance size and and quartiles of pre-inheritance wealth and income of parents, holding other controls at their means. Vertical lines reflect the 95 percent confidence interval.

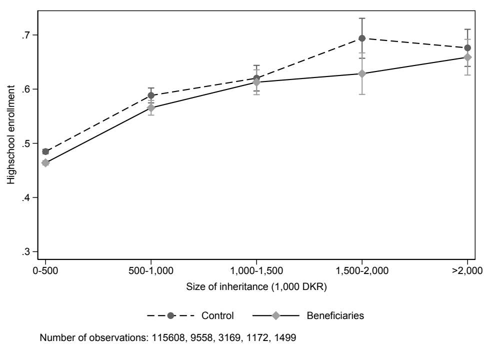
(a) 1st wealth quartile



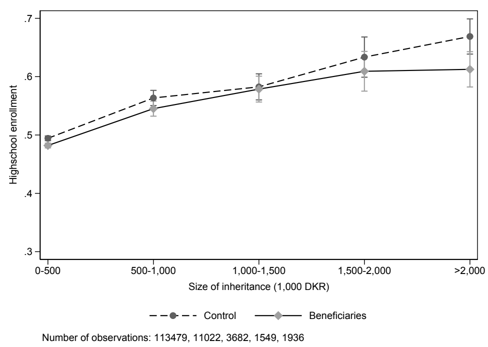
(b) 1st income quartile



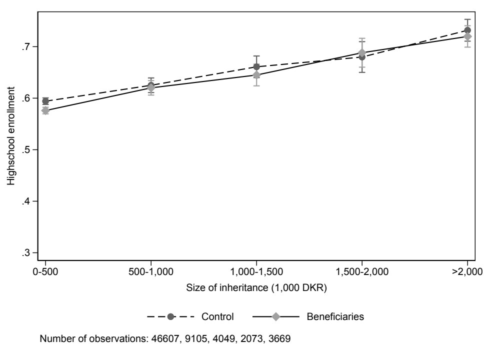
(c) 2nd and 3rd wealth quartile



(d) 2nd and 3rd income quartile



(e) 4th wealth quartile



(f) 4th income quartile

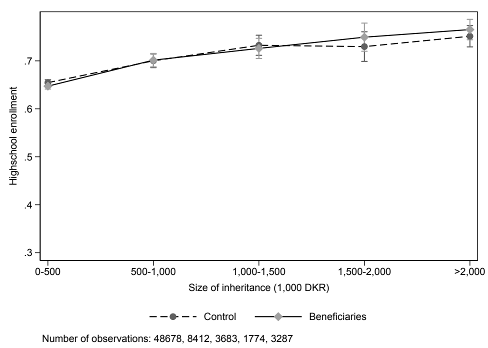
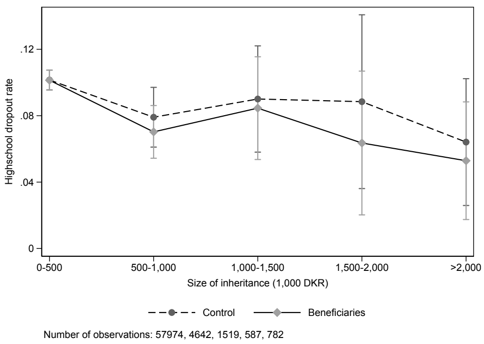


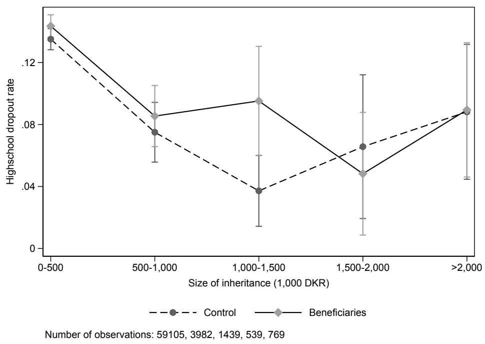
Figure A.4
Marginal effects on high school drop out rate, by pre-inheritance wealth and income

This figure shows marginal effects on high school drop out rate by inheritance size and and quartiles of pre-inheritance wealth and income of parents, holding other controls at their means. Vertical lines reflect the 95 percent confidence interval.

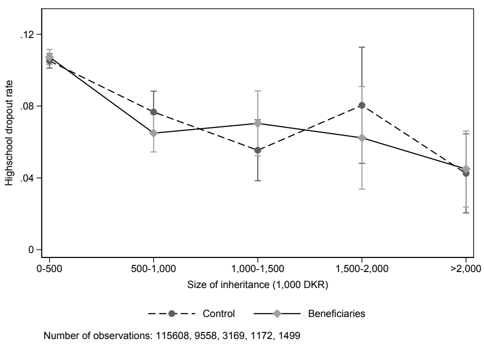
(a) 1st wealth quartile



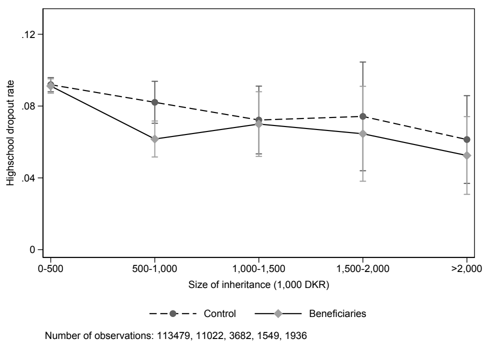
(b) 1st income quartile



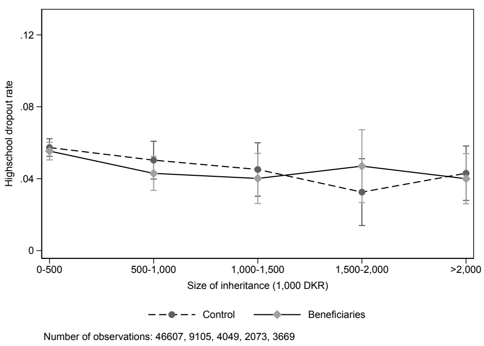
(c) 2nd and 3rd wealth quartile



(d) 2nd and 3rd income quartile



(e) 4th wealth quartile



(f) 4th income quartile

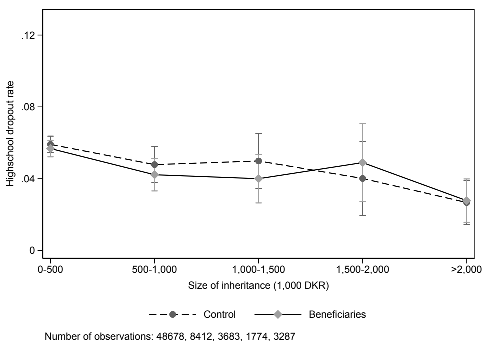
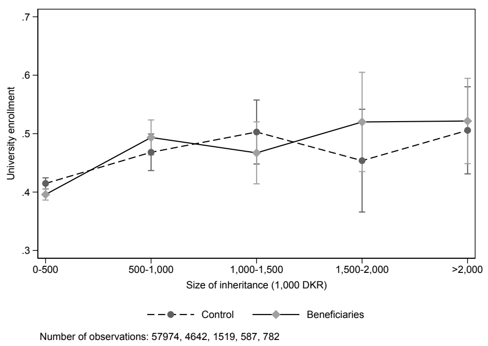


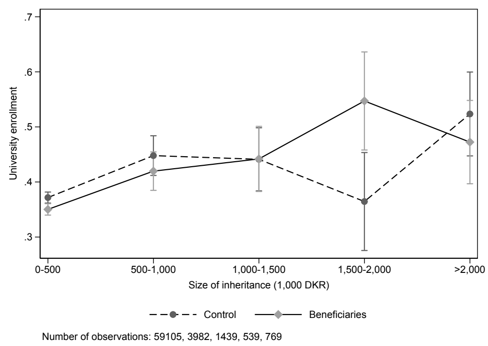
Figure A.5
Marginal effects on university enrollment, by pre-inheritance wealth and income

This figure shows marginal effects on university enrollment by inheritance size and and quartiles of pre-inheritance wealth and income of parents, holding other controls at their means. Vertical lines reflect the 95 percent confidence interval.

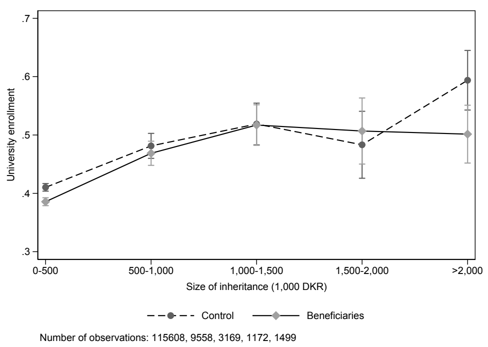
(a) 1st wealth quartile



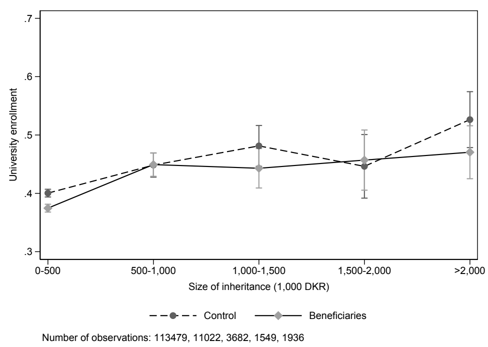
(b) 1st income quartile



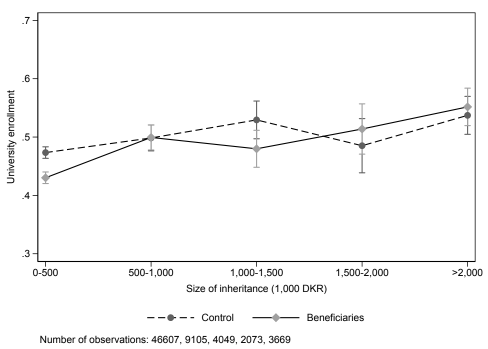
(c) 2nd and 3rd wealth quartile



(d) 2nd and 3rd income quartile



(e) 4th wealth quartile



(f) 4th income quartile

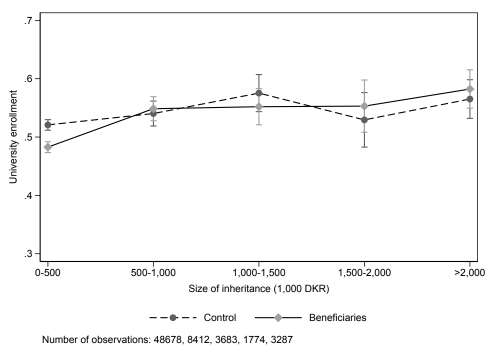
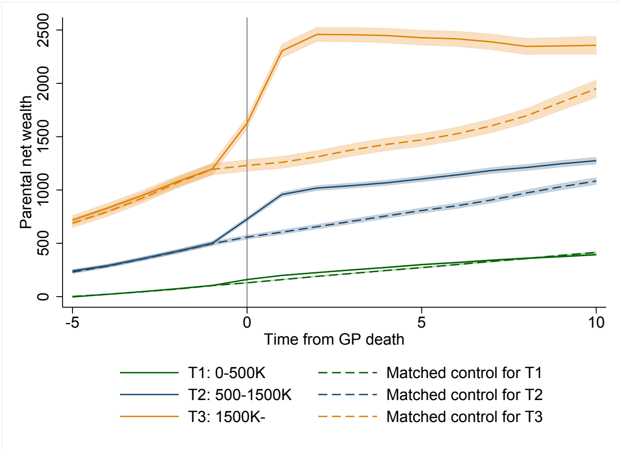


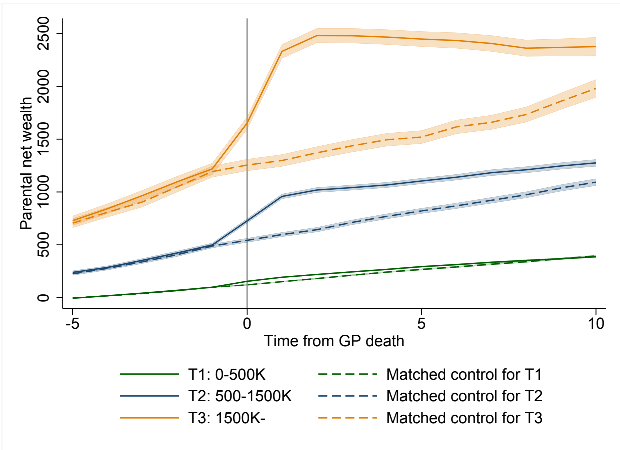
Figure A.6
Wealth of beneficiaries - different matching procedures

This figure plots mean net wealth of the matched parent pairs in the time around inheritance, by size of inheritance. Panel (a) uses nearest neighbor matching on parental wealth. Panel (b) does exact matching on parental education, and panel (c) matches to families who also lose a grandparent, but do not inherit. Amounts are in 1000s 2015 DKK. Bands show 95 percent confidense intervals.

(a) Matching on parental wealth



(b) Matching on parental education



(c) Matching to other deaths

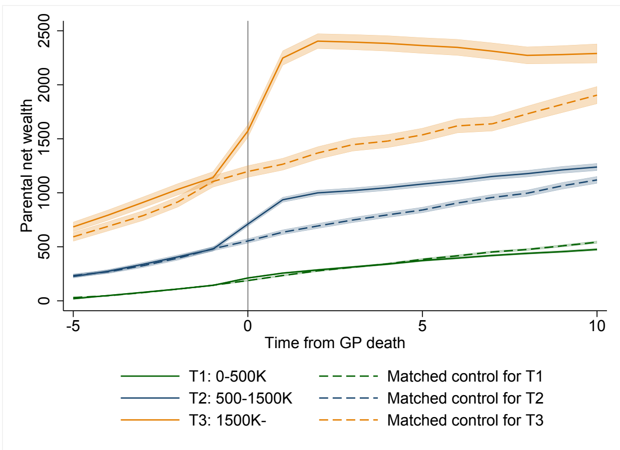
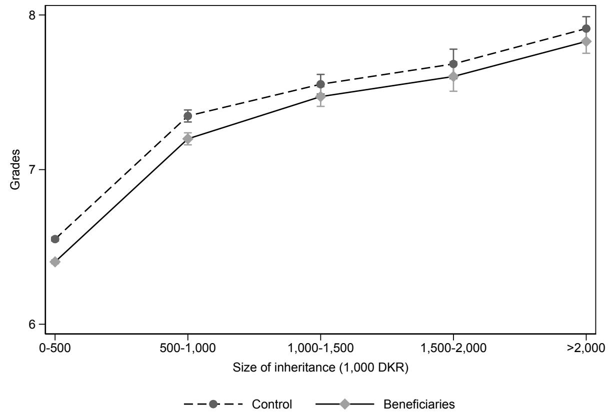
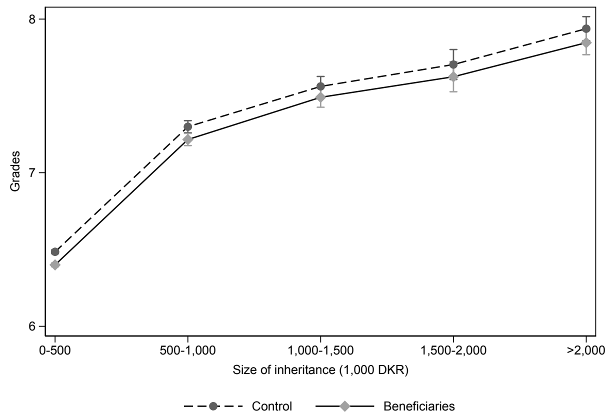


Figure A.7
Marginal effects on grades, by matching procedure.

(a) Matching on parental wealth



(b) Matching on parental education



(c) Matching to other deaths

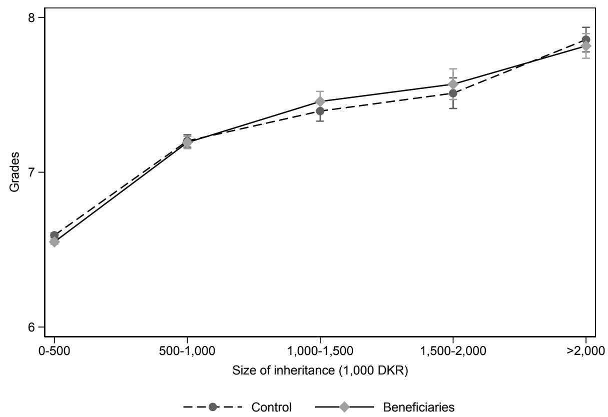


Table A.1
Balance test, parental wealth match

This table compares characteristics of all matched beneficiaries to the matched control group. Amounts are in 1000s 2015 DKK. ***, **, and * indicate statistical significance at the 0.1, 1, and 5 percentage levels.

	(1)		(2)		(3)	
	Beneficiaries		Control		Difference	
	mean	sd	mean	sd	b	p
Female (child)	0.50	0.50	0.50	0.50	0.00	(0.71)
Child age	5.05	2.82	5.05	2.82	0.00	(1.00)
Mother's age	35.24	5.65	33.76	5.51	1.49***	(0.00)
Father's age	38.04	6.34	36.42	6.46	1.62***	(0.00)
Parental education length (years)	14.62	2.21	14.81	2.19	-0.19***	(0.00)
Parental income	700.11	283.38	700.64	285.42	-0.53	(0.63)
Parental wealth	194.49	1045.56	192.86	1037.80	1.63	(0.69)
Living grandparents	2.95	0.87	2.95	0.87	0.00	(1.00)
Potential inheritance	738.26	941.39	740.63	944.31	-2.37	(0.52)
Observations	131668		131668		263336	

Table A.2
Balance test, parental education match

This table compares characteristics of all matched beneficiaries to the matched control group. Amounts are in 1000s 2015 DKK. ***, **, and * indicate statistical significance at the 0.1, 1, and 5 percentage levels.

	(1)		(2)		(3)	
	Beneficiaries		Control		Difference	
	mean	sd	mean	sd	b	p
Female (child)	0.50	0.50	0.50	0.50	-0.00	(0.72)
Child age	5.05	2.82	5.05	2.82	0.00	(1.00)
Mother's age	35.20	5.64	33.67	5.53	1.53***	(0.00)
Father's age	37.99	6.32	36.35	6.46	1.63***	(0.00)
Parental education length (years)	14.63	2.19	14.66	2.19	-0.03***	(0.00)
Parental income	699.40	280.96	699.47	282.21	-0.06	(0.95)
Parental wealth	187.84	1032.39	185.49	1019.49	2.35	(0.56)
Living grandparents	2.96	0.86	2.96	0.86	0.00	(1.00)
Potential inheritance	736.56	937.20	732.78	926.74	3.79	(0.30)
Observations	129578		129578		259156	

Table A.3
Balance test, matching to other deaths

This table compares characteristics of all matched beneficiaries to the matched control group. Amounts are in 1000s 2015 DKK. ***, **, and * indicate statistical significance at the 0.1, 1, and 5 percentage levels.

	(1) Beneficiaries		(2) Control		(3) Difference	
	mean	sd	mean	sd	b	p
Female (child)	0.50	0.50	0.50	0.50	-0.00	(0.16)
Child age	5.15	2.81	5.15	2.81	0.00	(1.00)
Mother's age	35.72	5.43	35.47	5.41	0.25***	(0.00)
Father's age	38.46	5.99	38.30	6.35	0.16***	(0.00)
Parental education length (years)	14.81	2.16	14.91	2.19	-0.10***	(0.00)
Parental income	718.13	288.37	718.00	289.79	0.12	(0.93)
Parental wealth	245.36	1092.47	245.02	1090.39	0.34	(0.95)
Living grandparents	2.95	0.76	2.95	0.76	0.00	(1.00)
Potential inheritance	864.03	989.62	775.53	873.14	88.50***	(0.00)
Observations	93600		93600		187200	

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