Fire Sales and House Prices:

Evidence from Estate Sales due to Sudden Death*

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Abstract: This study investigates when forced sales of real estate turn into fire sales by using a natural experiment which allows us to separate supply and demand effects: Forced sales result from sudden death of house owners and are thus unrelated to current market conditions. We find that forced sales result in fire sale discounts. Discounts increase when the sale is urgent, market conditions are poor, and the seller is financially constrained. Overall, our study identifies when forced sales lead to fire sale discounts, and highlights that fire sales occur even in the absence of temporary demand shocks.

JEL Classifications: D14, R31

Keywords: Fire sales; Real estate; Financial constraints; Sudden death.

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* We thank Rui Albuquerque, John Campbell, Sudipto Dasgupta, Mark Lane, Abhiroop Mukherjee, Tarun Ramadorai, Rik Sen, Dragon Tang, Ania Zalewska, and seminar participants at Aarhus University, American Real Estate Society 2013 Meeting, American Real Estate and Urban Economics Association 2015 Meeting, Australasian Banking and Finance Conference 2013, Boston University, Chinese University of Hong Kong, Copenhagen Business School, European Finance Association 2013 Meeting, Hong Kong Baptist University, Hong Kong University of Science and Technology, National University of Singapore, Nanyang Technological University, Paris School of Economics, University of Auckland, University of Bergen, and Victoria University for helpful comments and suggestions. We are grateful to the Danish Social Science Research Council for financial support through project 11-104456.

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1. Introduction

Forced sales of assets at fire sale discounts typically occur because of bankruptcy or financial distress. Such sales are forced because the seller cannot satisfy an outstanding obligation without selling assets, and the price is discounted because financial distress tends to be contagious within an industry (Lang and Stulz, 1992). The highest potential bidder may therefore be facing financial constraints of their own and be unable to buy the assets (Aghion, Hart, and Moore, 1992; Shleifer and Vishny, 1992, 2011). As a result, discounts on distressed assets are substantial. For instance, Pulvino (1998) shows that used planes sold by distressed airlines bring 10% to 20% lower prices than planes sold by unconstrained airlines.

Fire sale discounts might also be triggered by search friction in asset markets (Albuquerque and Schroth, 2012). For instance, real estate search theories (Wheaton, 1990; Krainer, 2001; Novy-Marx, 2009; and Piazzesi, Schneider, and Stroebel, 2012), suggest that the valuation of real estate depends on the quality of the match with the potential buyer. If search frictions cause fire sales discounts, discounts should arise irrespective of the market conditions whenever sellers cannot wait for high-valuation buyers to arrive.

Although prior literature has documented that fire sale discounts exist and can be substantial (Pulvino, 1998; Coval and Stafford, 2007; Eckbo and Thorburn, 2008; Campbell, Giglio, and Pathak, 2011; Albuquerque and Schroth, 2012), it has been difficult to empirically identify when forced sales result in fire sale discounts. Forced sales are typically triggered by industry-wide or asset specific adverse shocks that affect both supply and demand for the asset. For instance, foreclosure and bankruptcy sales tend to occur when house prices fall, which makes it difficult to isolate the effect of forced sales on prices from the effect of the confounding shock. Empirical identification of conditions under which forced sales turn into fire sales therefore requires that one can separate supply and demand effects.

This study investigates when forced sales turn into fire sales by using a natural experiment in which a random asset independent of market conditions is forced to be sold over a short time horizon. We exploit forced sales resulting from sudden deaths of house owners. The advantages of our identification strategy are threefold. First, sudden deaths provide a close to random draw of house owners which ensures that individual and house characteristics are exogenous. Second, forced sales due to sudden deaths are unrelated to the current supply and demand for the asset. This allows us to identify market conditions under which forced sales occur at fire sale discounts. Third, estate sales are forced to be resolved within 12 month because of the institutional environment. This allows us to identify urgent sales as the deadline nears.

Collectively, these attributes ensure that sales in our sample are triggered by unanticipated events, which allow us to identity when forced sales leads to fire sales discounts. In comparison, prior literature has estimated the discount on forced sales due to financial distress (Pulvino, 1998), mutual fund outflows (Coval and Stafford, 2007), bankruptcy (Eckbo and Thorburn, 2008; Campbell, Giglio, and Pathak, 2011).[1] or foreclosure (Shilling, Benjamin and Sirmans, 1990; Forgey, Rutherford and VanBuskirk, 1994; Hardin and Wolverton, 1996; Campbell, Giglio, and Pathak, 2011). While these studies document substantial discounts, they are unable to identify whether discounts arise as a result of demand and/or supply conditions. To this end, the main contribution of this study is to fill this gap.

Our identification strategy derives from the institutional setting surrounding inheritance cases in Denmark. The Danish Inheritance Act requires estates to be settled in probate court within 12 months after the death. As a result, the suddenly deceased's house is either forced to be sold or forced to be transferred to beneficiaries. Due to the institutional setting it is economically unattractive to transfer

[1] Campbell, Giglio, and Pathak (2011) also examine house sales occurring in a window from 3 years before to 3 years after the death of the owner, and find an average discount of 5%. They argue that the pricing pattern for death-related sales suggests that the discount may be due to poor maintenance, because the discount does not depend on the timing of the sale relative to the timing of a seller's death. While our approach of using sudden deaths, at first glance, appears to be similar to theirs, we find that discounts depend on the timing of the sale relative to the death.

ownership with the purpose of renting out or postponing the sale.[2] Family transfers mainly occur for non-pecuniary reasons; either because a beneficiary already lives in the house or subsequently moves into the house.[3] More importantly transfers to beneficiaries are unrelated to current market conditions and observable house characteristics, and only 7% of all family transfers are resold within 2 years.[4] Consequently, more than 90% of all houses in our sample end up being sold at arm's length, and the potential bias resulting from transfers of ownership within the family is thus likely to be small.

Our empirical identification of estates relies on a conservative medical definition of sudden death and unique cause-of-death data from official death certificates to identify 6,854 suddenly deceased house owners from 1992 to 2009. We identify the first transaction of the house following the death and focus exclusively on arm's-length transactions in which the buyer is unrelated to the deceased or the beneficiaries. Out of a total of 877,559 house sales from 1992 to 2010, we identify 6,329 forced sales.

To examine the effect of forced sales we follow a standard approach in real estate economics and regress the logarithm of the house price on house characteristics, calendar month indicators, and municipality-year fixed effects. We find that forced sales result in an average discount of 8.9%. The discount is increasing as the deadline nears. Sales shortly after the sudden death occur at market prices, while sales in the last three months before the deadline result in an average discount of 14.0%.

Although asking prices might decline with the time on the market, the pricing pattern suggests that this cannot alone explain the estimated discount. Under the alternative hypothesis of a time on the market

[2] Transfers of ownership to beneficiaries can legally occur at a discount equivalent to 15% of market value. Thus, the tax benefit of transferring ownership to beneficiaries equals 2.25% of the house value (= 15% discount times the 15% estate tax). The net benefit is low, and in many cases negative, because of transaction costs, foregone cash flows, yearly property taxes (at least 1% of the property value), agency costs due to rent control, limited contractual freedom, and restrictive planning and zoning laws that require houses to be occupied or for sale.

[3] In almost half of the family transfers a beneficiary lived in the house prior to death, and in 83% of the family transfers a beneficiary lives in the house after the family transfer.

[4] In the online Appendix A we show that transfers of ownership to beneficiaries are unrelated to the house price growth and observable house characteristics. In addition we find no difference in the tax authorities' assessment of house value (prior to death) between houses that are transferred to beneficiaries or sold, respectively.

effect, one would expect to observe a premium on early forced sales and a discount on late forced sales because we benchmark to realized prices for average time on the market, which according to the Association of Danish Mortgage Banks is 145 days.[5] We observe, on the contrary, that early sales occur at market prices and late sales occur at deep discounts. In addition, Genesove and Mayer (1997) and Levitt and Syverson (2008) show that sellers who keep their houses on the market longer realize higher prices.[6]

Having established that forced sales result in discounts, we examine how marked conditions affect the discount. We find an average discount of 7.5% during years when prices increased by 10.0% or more, while the discount during years when house prices contract averages 12.6%. Thus, the discount is 5.1% larger during years with contracting house prices (busts), consistent with theoretical predictions in Shleifer and Vishny (1992), where discounts result from negative industry-wide shocks. Our findings of discounts during booms highlight that discounts arise when sales are urgent even in the absence of an adverse shock affecting the demand for the asset.

To understand the importance of the financial position of the seller in determining the forced sale discount, we identify financially constrained estates and beneficiaries for whom alternatives to selling are limited. In our setting the seller's financial position is exogenous to the forced sale because the sale is triggered by the sudden death. We can therefore empirically identify the effect of financial constraints on fire sale discounts. We classify estates as financially constrained if their net wealth excluding house equity is negative. These estates all have positive net wealth, but the wealth is tied in the house. To meet liabilities and pay the estate tax the house therefore needs to be sold. As expected, forced sales of houses by

[5] The Association of Danish Mortgage Banks has data on time on the market from 2004, and from 2004 to 2010 the average time on the market is 145 days. Time on the market is a function of market conditions. In years where prices increase time on the market is lower than in years with declining prices. We find smaller (larger) discounts when prices increase (decrease), which is the opposite of the alternative hypothesis of a time on the market effect driving the results.

[6] Ideally we would control directly for time on the market effects. But this also have several shortcomings. Most importantly we do not have the data and cannot obtain it. Secondly even if we identified sales through online postings we would have to consider the selection process of listed houses which were never sold, because no price high enough was offered.

financially constrained estates occur at an incremental discount of 6.4% relative to other forced sales. The time pattern of discounts for sales by financially constrained estates reveals substantial discounts of 5% to 10% for early sales, while sales shortly before the deadline occur at discounts of 15% to 25% for financially constrained estates. Financial constraints are, thus, an important determinant of fire sale discounts.

One concern with our results is that discounts might be driven by unobserved heterogeneity in the quality of houses. Although sudden deaths provide a close to random draw of houses and their owners, which limits concerns about unobserved heterogeneity, we further examine two subsamples for which such concerns are limited. The first subsample focuses exclusively on forced sales of houses owned by individuals who died in a traffic accident where the assumption about a random draw of property owners is more likely to be satisfied. This subsample also rules out concerns about whether discounts relate to superstition, as traffic accidents, by definition, occur outside the deceased's house. The second subsample entails restricting the sample to houses that are sold with tenants, and therefore remain occupied while on the market. For these subsamples, we find discounts of similar magnitude.

Overall, the results are consistent with the theoretical predictions of Shleifer and Vishny (1992). Discounts are determined by the urgency of the sale, market conditions, and the financial position of the seller. Perhaps more surprisingly we find evidence of discounts, although smaller, during booms. These results are consistent with Albuquerque and Schroth (2012), who model asset sales by use of a search model, as well as real estate search theories (Wheaton, 1990; Krainer, 2001; Novy-Marx, 2009; and Piazzesi, Schneider, and Stroebel, 2012). Search frictions in the housing market result in fire sale discounts when sellers are forced to find buyers over short time horizons.

Understanding when forced sales lead to fire sale discounts is important because fire sales and efforts to avoid them have implications for a wide range of financial and economic outcomes. For instance, fire sales affect the structure and terms of debt contracts (Shleifer and Visnhy, 1992; Benmelech, Garmaise, and

Moskowitz, 2005; Benmelech and Bergman, 2009, 2011; Ortiz-Molina and Phillips, 2010). Fire sales might also have spillover effects that can lead to downward spirals or cascades in asset prices and net worth of market participants (Kiyotaki and Moore, 1997; Gromb and Vayanos, 2002; Coval and Stafford, 2007; Campbell, Giglio, and Pathak, 2011) and creditors (Acharya, Bharath, and Srinivasan, 2007), resulting in real effects through reduced investment and output (Kiyotaki and Moore, 1997; Ivashina and Scharfstein, 2010; and Shleifer and Vishny, 2010). In relation to these important issues, our results provide new insights about when forced sales are likely to result in costly fire sales.

Section 2 outlines empirical strategy, presents our data, and provides summary statistics. Section 3 presents the results, while Section 4 considers alternative specifications. Section 5 concludes.

2. Estate sales due to sudden death

We assemble a unique dataset from Denmark that allows us to identify house owners who suddenly die and to subsequently follow the sale of their houses by the estate. In addition to supplying micro-data from administrative registers, the Danish case also provides us with a legal environment in which estates have to be settled within 12 months following the death. The probate court will only in rare cases extend the liquidation period beyond 12 months.[7] As the deadline nears, the probate court will schedule a meeting to finally settle the estate. This meeting legally has to occur, at the latest, 3 months after the end of the liquidation period and, hence, 15 months after the death. If the deceased's house is not sold at this point, the probate court may order the house to be auctioned off.

To simplify the analysis we focus exclusively on estates where all beneficiaries are offspring, as children, according to the Danish Inheritance Law of 1964, will inherit the estate in proportional shares in

[7] In more involved estates, a lawyer may be appointed to resolve the estate on behalf of the beneficiaries. In such cases, the legal deadline for settlement of the estate is 24 months. Lawyers are, according to the Ministry of Finance (1999), appointed to 8.4% of all estates, and this typically occurs whenever disputes exist among beneficiaries.

such cases.[8] The net worth of such estates is subject to a 15% estate tax for offspring if it exceeds DKK 191,000 (EUR 25,638) in 1998. This threshold is inflated by a price index in subsequent years.

Identification of estates is facilitated by the institutional environment. Danish law requires that a death certificate be issued by a doctor when a citizen dies. If the person dies at home, the death certificate is filled out by the personal doctor or the emergency doctor on duty (*Lægevagten*). If the person dies in the hospital, a doctor at the hospital will issue the death certificate. The death certificate classifies the cause of death according to guidelines established by the World Health Organization (WHO).

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 purpose of establishing the net worth of the estate, 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, it takes, on average, 9 months to resolve an estate. During this period, beneficiaries are entitled to appoint the real estate agent and approve the sale of houses.

A. Data sources

[8] The default sharing rule can only partially be offset by the existence of a will that, by Danish law, must be publicly available before the death. Although opting out through wills is possible in Denmark, the inheritance law ensures that children will inherit at least 50% of the estate in the cases we consider. Moreover, opting out of the default sharing rule is extremely rare, as only 2% of the empirically relevant individuals in Denmark have drafted a will (Ret og Råd 2008).

Our data cover the universe of adult Danes in the period between 1990 and 2010. Our dataset contains economic, financial, and personal information about decedents and beneficiaries. We derive data from five different sources made available through Statistics Denmark; the sources are:

1. Causes of deaths from the Danish Cause-of-Death Register at the Danish National Board of Health (*Sundhedsstyrelsen*). This dataset classifies the cause of death accordingly to WHO's International Classification of Diseases System.[9] The source of these data is the official death certificates that are issued by a doctor immediately after the death and convey a medically qualified opinion on the cause of death. We have obtained the cause of death for all Danish citizens who passed away between 1992 and 2009.

2. House transactions from the Danish Tax and Customs Administration (*SKAT*). SKAT receives the information from The Danish Gazette (*Statstidende).* Public announcement in The 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 prices of house transactions over the sample period.

3. Individual characteristics of houses from the Housing Register (*Bygnings- og Boligregister*, BBR), which has detailed information on all houses in Denmark. The information is available at the end of each year, and year-to-year changes are supplied by municipalities based on planning permissions, which house owners are obliged to apply for before undertaking any significant alteration of their property. From this dataset, we obtain individual characteristics of all houses in Denmark.

4. Individual and family data from the official Danish Civil Registration System (*CPR Registeret*). These records include the individual's personal identification number (*CPR numbers*); gender; age; CPR numbers of nuclear family members (parents, siblings, and children); and the individual's marital history (marriages, divorces, and widowhoods). We use these data to identify all individuals' legal parents.

[9] WHO's International Classification of Diseases, ICD-10, is the latest in a series that has its origin in the 1850s. WHO took over the responsibility of ICD at its creation in 1948, and the system is currently used for mortality and morbidity statistics by all Member States. The ICD-10 standard replaced the ICD-8 standard in 1994.

5. Income and wealth information from the official records at the Danish Tax and Customs Administration (*SKAT*). This dataset contains wealth information by CPR numbers for the entire Danish population. The tax authorities receive this information directly from the relevant sources: Financial institutions supply information on their customers' deposits, interest paid (or received), security investments, and dividends. The data from the tax authorities also contain an assessment of house values, which forms the basis for the property value tax and the municipality land tax.[10] The assessment is carried out every other year, and is an estimate of the property's cash price 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. The assessment is carried out at the municipality level and incorporates factors that are unobserved in the data from the Housing Register. The assessment of house values by the tax authorities therefore provides us with a house-specific estimate of the expected price. We have obtained access to data on wealth and house valuations from 1990 to 2010.

Taken together, these data sources allow us to identify forced sales of houses, and examine whether forced sales result in lower prices relative to comparable houses.

B. Data construction

To identify forced sales, we link the data on deceased individuals to the data on house ownership and sales. We focus on the house market as the markets for apartments and condominiums in Denmark are geographically clustered and cater to specific socio-economic groups. The house market, on the other hand covers all geographic locations, and has widespread participation by most segments of the population.

[10] House owners pay a progressive annual property tax starting at 1% of the assessed property value, and an annual municipality land tax varying between 0.06% and 0.24% of the assessed value of the lot.

The starting point of our analysis is to identify estates. In total, we identify 208,283 estates between 1992 and 2009. Table 1 shows the individual characteristics of the decedents and their estates. We identify the cause of death with the purpose of selecting a sample of estates resulting from sudden and unexpected death. To identify sudden deaths, we follow Andersen and Nielsen (2011, 2012), who identify relevant ICD codes from related medical literature combined with a thorough inspection of WHO's detailed classification system.[11] According to this definition, 48,938 of the estates result from sudden deaths.

Among estates resulting from sudden death, we identify 6,854 estates with 7,022 houses that are forced to be sold. The final step in our sample selection entails determining whether sales occur at arm's length because transfers within the family are likely to occur at discounted prices to minimize the estate tax. Out of 7,022 houses, ownership is transferred to a beneficiary in 693 cases. In 311 (45%) of these cases a beneficiary already lived in the house before the death event, and in 572 of the family transfers (83%) a beneficiary subsequently lives in the house. The remaining 121 (17%) transfers within the family are subsequently rented out. In the online Appendix B we examine the propensity to transfer ownership within the family and find that it is unrelated to current market conditions and observable house characteristics. We also note that few of these transfers subsequently are resold. Only 49 out of 693 (7%) transfers of ownership within the family are resold after 2 years. We conclude that family transfers appear to occur for non-pecuniary reasons and that the potential bias resulting from transfers of ownership within the family is likely to be small due to the institutional setting. In the following we focus exclusively on arm's lengths transactions. Our final sample therefore includes 6,181 estates with 6,329 houses where the beneficiaries are forced to sell the house to settle the estate.

In our final sample, the deceased has net wealth of DKK 987,200 (EUR 132,500), of which property wealth contributes the majority. The deceased in the forced sale sample has significantly higher wealth than

[11] Appendix A in the online appendix provides an overview of the definition and corresponding ICD codes.

all estates that result from sudden death because we condition on house ownership. We also note that despite our use of a medical definition of sudden deaths, the decedents in our sample are 74.2 years old, which spurs concerns about whether our analysis will be confounded by unobserved house characteristics such as maintenance. In the empirical analysis, we address this concern by focusing on i) traffic accidents, and ii) use of propensity score matching on the seller's age.

Table 2 presents summary statistics for all house sales as well as our final sample of forced sales. In total, our data include 877,559 house sales, of which 6,329 (0.7%) are classified as forced. Panel A reports individual characteristics of houses. The average house has an internal size of 128.2 square meters (excluding basement), has a lot of 879.3 square meters, and is 50.9 years old. One out of three houses has a basement, and the average size of basements is 31.5 square meters. In comparison, forced sale houses have smaller interior size and lots, and are slightly older.[12]

Panel B reports the average house price as well as the tax authorities' assessment of the value prior to the transaction. The average house price over the sample period equals DKK 1,091,800 (EUR 146,500). In comparison, forced sales occur at lower prices. The average price of a forced sale is DKK 959,500 (EUR 128,800). While the differences in house characteristics collectively suggest that houses owned by the suddenly deceased should be priced lower, the tax authorities' assessment of the value, which takes into account individual characteristics, suggests that forced sales result in large discounts. The average assessed house value for forced sales is DKK 1,099,300, compared to DKK 1,126,000 for non-forced sales. If the assessed value provides an unbiased estimate of the value, we can estimate the discount on forced sales as the difference between the house price and the assessed house value relative to non-forced sales. For forced sales, the difference is equivalent to DKK 139,800 (12.7%), compared to DKK 33,300 (3.0%) for other sales. This yields a discount of DKK 106,500 (9.7%), which is statistically significant at the 1% level.

[12] Appendix C in the online appendix shows the geographic and seasonal distribution of house sales.

Thus, by using the tax authorities' assessment of value prior to the transaction as benchmark, we obtain a 9.7% difference-in-differences estimate of the forced sale discount.

3. Empirical results

A. A model of house prices

We estimate the relationship between the price of houses and their characteristics using a hedonic regression. The main equation for estimating the forced sale discount is specified in Equation (1), where the dependent variable is the log price, y_{ijt} , of house *i* in municipality *j* in year *t*:

$$y_{ijt} = \alpha_{jt} + \beta' X_i + \gamma' F_i + \epsilon_{ijt}, \qquad (1)$$

where a_{jt} captures municipality-year fixed effects, X_i is a vector of house characteristics, and F_i is an indicator for forced sales. House characteristics include: interior size, lot size, basement indicator, basement size, number of bathrooms, house age, house age squared, and calendar month indicators.

Table 3 reports our estimates of the coefficient of house characteristics, β, and the forced sale discount, γ. For brevity we omit the coefficients on house characteristics from Table 3, and report them in the online Appendix D. We note that the coefficients on house characteristics all have the expected sign and plausible magnitudes. In Column 1, we find an estimated coefficient for the indicator for forced sales of -0.0681, corresponding to a price discount of 1-exp(-0.0681) = 6.6%.

In Column 2 we include the tax authorities' assessment of house value among our control variables to alleviate the concern that our location-fixed effects do not properly control for unobserved heterogeneity in location. The main idea is that the tax authorities have more detailed data on locations than we do. For instance, the tax authorities use access to recreational facilities like beaches, forests, or lakes and distance to public transportation and infrastructure like schools when assessing the house value. Because our specification already includes location-year fixed-effects, the coefficient on (log. of) assessed house value captures house specific variation in prices beyond the house characteristics and location-year

fixed effects included in the hedonic model. Consistently, we find that houses with high assessed value are sold at higher prices. More interestingly, we note that the discount on forced sales increases from 6.6% to 8.9% when we include the tax authorities' assessment of house value as control.

Column 3 in Table 3 estimates the discount conditional on the time of sale relative to the death. If the estimated discount is related to the sale being forced, we expect the discount to be larger for sales that occur close to the 12-month deadline. In Column 3, we therefore include an interaction term between the forced sale indicator and the number of months that have passed after the death. The discount increases by 0.7% per month, implying that sales that occur right after the death have a small discount, whereas sales shortly before the deadline are priced around 12.7% lower than comparable houses.[13]

In Column 4, we examine whether the discount is increasing as the time to the deadline nears. The average forced sale occurs 193 days after the death.[14] We include four indicators for forced sales depending on the time lag between the death and the sale. Forced sales occurring 0-90 days after the death are sold at prices identical to comparable houses. Forced sales after 91 to 180 days and 181-270 days have an average discount of 8.1% and 12.7%, respectively. Forced sales after 271 days (9+ months), and hence shortly before the deadline, occur at a 14.0% discount. Urgent sales lower prices, which is consistent with Mayer (1995, 1998), who studies the effect of urgent sales on prices in real estate auctions.

As mentioned in Section 2, it is possible that some sales occur more than 12 months after the death. The deadline can be extended if i) a lawyer is appointed to resolve the estate due to family disputes; ii) the probate court orders the house to be liquidated at an auction; or iii) a sale is being negotiated.[15] Out of 6,329 forced sales in our sample, 728 (11.5%) are sold more than 12 months after the death. Of these 728

[13] The discount after 12 months is calculated as the sum of the coefficients on the forced sales indicator and the coefficient on the interaction term month after death: (1-exp(-0.0508)) + (1-exp(12*-0.0067) = 12.7%.
[14] The average time on the market between 2004 and 2010 is 145 days according to Realkreditrådet (2014).
[15] Formally, beneficiaries have 3 months to report the final outcome of the liquidation of the estate to the probate court. This practice stretches the deadline to 15 months if the beneficiaries can manage to schedule the appointment with the probate court at the last possible day.

sales, more than 65% are sold in the following 6 months (i.e., 12 to 18 months after the death). Only 85 (1.3%) sales occur more than 24 months after the death. In unreported regression, we have extended the specification in Column 4 of Table 3 to differentiate between the timing of sales after 9 months. Sales after 9 to 12, 12 to 15, 15 to 18, and 18+ months occur at discounts of 12.6%, 13.0%, 18.0%, and 16.2%, respectively. In comparison, the estimates in Column 4 of Table 3 for sales after 6 to 9, and after 9+ months, yield discounts of 12.7% and 14.0%, respectively.

The pricing pattern suggests that time on the market cannot alone explain the estimated discount. If sellers gradually lower their asking prices over time, our hedonic pricing model will price houses relative to the average time on the market. On average it takes 4.8 months (145 days) to sell a house in Denmark according to the Association of Danish Mortgage Banks. If time on the market is driving the estimated time pattern, one would expect to observe a premium on early forced sales and a discount on late forced sales. We observe, on the contrary, that early sales occur at market prices and late sales occur at deep discounts. Overall, the time pattern in columns 3 and 4 of Table 3 shows that discounts increase as the deadline nears: forced sales close to deadlines occur at fire sale discounts.

B. The effect of market conditions on the forced sale discount

In the theoretical model by Shleifer and Vishny (1992), discounts occur because the industry buyers, who are the most natural candidates for buying the asset, might themselves be financially constrained and, hence, unable to bid when the assets are being liquidated. Thus, it is natural to hypothesize that market conditions will affect the discount because forced sales do not have the option of withdrawing the house from the market. Because forced sales in our sample are exogenous to market conditions, we can directly identify the interaction between forced sale discounts and market conditions.

In Table 4, we examine the magnitude of the forced sale discount during booms and busts. Booms are defined as years during which house prices increased by more than 10.0%. Busts are defined as years having declining house prices. In Column 1, we find that discounts are 1.9% lower during booms, and in Column 2, we find a 4.3% higher discount during busts.[16] When we include the boom and bust effects together in Column 3, we find an average discount during booms of 7.5%, while the discount during busts averages 12.6%. Thus, discounts are 5.1% larger in busts than in booms. In Column 4, we interact forced sales with the house price growth in each year, and find larger discounts when prices are declining.

In Column 5 of Table 4, we examine the interaction between the local market activity and the forced sale discount. We use the total number of house sales in each municipality each year (divided by 100) to measure the level of local housing market activity. Any direct effect of market activity on prices is captured by the municipality-year fixed effect. Column 5 in Table 4 shows that in areas with few house sales per year, the average discount on forced sales equals 10.0%. As the local market becomes more active, the discount declines. In the most active local market the forced sale discount equals 7.2%. In Column 6, we interact the forced sale indicator with the local market turnover, which is defined as the number of sales over the number of houses in each municipality in each year measured in percentage points. Again we find smaller discounts in more active local markets, whereas discounts are larger in thin local markets.

C. The effect of financial constraints on the forced sale discount

Prior studies of forced sales (e.g., Pulvino 1998; Eckbo and Thorburn, 2008; Campbell, Giglio, and Pathak, 2011) show that discounts are large when the seller is financially distressed. Foreclosure sales typically occur at prices that are 20% below market prices of comparable homes (Shilling, Benjamin and

[16] A joint test of the forced sales indicator and the forced sales during boom indicator reveals that the discount of 7.5% during booms in Column 1 of Table 4 is significant at the one percent level.

Sirmans, 1990; Forgey, Rutherford and VanBuskirk, 1994; Hardin and Wolverton, 1996; Campbell, Giglio, and Pathak, 2011), although part of this discount can be attributed to the market timing and poor physical condition of foreclosed homes (Clauretie and Daneshvary, 2009). In our setting, forced sales are unrelated to the financial conditions of the seller and the state of the economy, which allows us to separate the effect of financial constraints from market conditions. From 1996 and onward, our data include information about the financial position of estates and beneficiaries. If the net wealth of the estate is tied in the house, the ability to pay ongoing expenses (e.g. property taxes and utility bills) is limited, and the liquidity need might force the beneficiaries to sell the house earlier at a lower price. The financial position of the estate also affects the beneficiaries' ability to incur the 15% estate tax without selling the house. While we stress the importance of financial constraints it should be noted that the estates in our sample generally have significant wealth providing them with sufficient means to maintain the house. Our measures of financial constraints are therefore likely to be unrelated to the quality of houses prior to the deaths.

We measure financial constraints by an indicator for estates with negative non-housing wealth. Due to the availability of data on financial positions, we restrict the sample to house sales between 1996 and 2010. As a result the number of observations is reduced from 877,559 to 687,216. Out of the 5,324 forced sales in this period, 1,001 (18.8%) of the estates are financially constrained according to our measure. Column 1 in Table 5 estimates the forced sale discount for such estates. We find a general discount of 7.5%, and an additional discount of 6.4% for forced sales by financially constrained estates. Thus, houses sold by constrained estates are priced 13.9% below comparable houses. In Column 2, we examine the effect of financially constrained beneficiaries on the discount. We find a negative incremental discount of 2.9% whenever all the beneficiaries are financially constrained. In Column 3, we include both effects and note that discounts are driven by sales by both financially constrained estates and beneficiaries.

If estates or beneficiaries are financially constrained or liquidity constrained, it is likely that they will sell earlier by lowering the asking price. If so, we expect to find even larger discounts once we control for the timing of the sales relative to the deadline. To examine the time pattern, we estimate the hedonic pricing model with indicators for the timing of the sale and interactions between these timing indicators and financially constrained estates. Figure 1 plots the estimated discounts. Forced sale discounts are larger for financially constrained estates and beneficiaries. Early sales occur at discounts between 5% and 10%, while sales shortly before the deadline occur at 15% to 25% discounts for financially constrained estates. In the online Appendices E and F we show the robustness of these results using a second measure of financial constraints which captures estates with low financial wealth.

4. Alternative specifications

In this section we address concerns related to the design of the experiment and the hedonic pricing model. We start by showing that our results are unlikely to be driven by unobserved house heterogeneity.

A. *Estimating the discount using forced sales due to traffic accidents*

While our reliance on sudden deaths intends to ensure that property owners are randomly selected, heart attacks and strokes might be related to attributes that affect an individual's decision to defer maintenance of the house. Focusing on traffic accidents effectively rules out this possibility. In total, we have 225 sales of houses owned by individuals who died in a traffic accident. Columns 1 and 2 of Table 6 report discounts of similar magnitude when we use only forced sales due to traffic accidents.

B. Propensity score matching on seller's age

To further ascertain that unobserved house characteristics related to the seller's age, like maintenance, are not confounding our result, we estimate the forced sale discount using a propensity score matching method. We use exact matching on municipality, year of sale, house age, and interior size vigintiles (twenty groups of equal frequency). The propensity score is calculated based on the seller's age. Column 3 in Table 6 reports a discount of 6.2%. In Column 4 of Table 6, we further restrict the sample to houses less than 15 years old because they require little maintenance. We find a discount of 9.5% for forced sales of newer houses. Given that the propensity score matching method compares houses sold by owners of the same age, the forced sales discount is unlikely to be driven by differences in maintenance.

C. Estimating the forced sales discount for houses with tenancies

An important difference between forced sales and normal sales relates to whether the house is occupied while on the market. Forced sales are typically unoccupied, while non-forced sales typically are occupied while on the market. Arguably this difference raises the concern that forced sales discounts might be driven by vandalism, a lack of regular cleaning, or poor maintenance. While this alternative story potentially can explain discounts, we note that it is inconsistent with several of our results. First, the alternative story predicts that discounts should monotonically increase with time on the market. We find that discounts increases as the deadline winds down, but remains relatively constant for houses that are sold after the deadline. Second, the alternative story cannot explain why we find incremental discounts for financially constrained estates and beneficiaries. The results in these specifications effectively controls for (unoccupied) time on the market, while the interaction terms with financially constrained estates and beneficiaries capture the incremental effects, which by construction cannot be explained by the alternative story.

Finally, we find forced sales discounts in the subsample of houses that are sold with tenants, and therefore remain occupied while on the market. Tenants are contractually liable for any vandalism, lack of regular cleaning, or poor maintenance during their occupancy irrespective of the change of ownership. Because new owners are obliged to take over existing tenancies, this subsample ensures that all houses remain occupied while on the market. In our sample of house sales, 61,200 houses are sold with tenants (7% of all house sales), and 445 of these are forced sales (7% of all forced sales). Column 5 of Table 6 reports a forced sales discount of 6% in this subsample. We conclude that unoccupied time on the market is unlikely to explain our results.

5. Conclusions

In this study we use a natural experiment to investigate when forced sales result in fire sale discounts. We use forced sales resulting from sudden death in an institutional environment in which estates have to be settled within 12 months after the death. We find that, on average, forced sales result in prices that are 8.9% lower than comparable houses. The discount increases as the time to the deadline nears. Forced sales close to the deadline occur at fire sale discounts of 14.0%.

More importantly, our experiment allow to separate supply and demand effects. We find larger forced sales discounts when the demand for the asset is low, and when the sales is urgent because the seller is financially constrained. The later results highlight that fire sales occur even in the absence of temporary demand shocks. Search friction in asset markets can lead to fire sales discounts when sellers are forced to find buyers over short time horizons.

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Table 1. Estates with forced house sales, 1992–2009

	All estates	Estate resulting from sudden death		
		All	With forced house sale	With forced house sale at arm's length
Age (years)	72.0	73.3	73.6	74.2
	(74.0)	(76.0)	(76.0)	(77.0)
Gender (% male)	43.6	45.4	52.3	51.0
	(0.0)	(0.0)	(1.0)	(1.0)
Net wealth (DKK 1,000)	383.1	366.6	987.4	987.2
	(44.5)	(50.0)	(665.3)	(673.0)
Property wealth (DKK 1,000)	253.8	234.5	860.0	858.2
	(0.0)	(0.0)	(655.3)	(658.9)
N	208,283	48,938	6,854	6,181

Note: This table shows descriptive statistics for estates from 1992 to 2009. Estates resulting from sudden deaths are identified using the World Health Organization's International Classification of Diseases (see Appendix A). Sudden deaths are caused by acute myocardial infarction, cardiac arrest; congestive heart failure, stroke, sudden deaths by unknown cause, traffic accidents, and other accidents and violence. Other accidents and violence do not include suicides or violence caused by relatives of the decedent. All other causes of death are classified as non-sudden. We report mean (and median) individual characteristics of the deceased: *Age* is measured in years; *gender* is an indicator for male; *net wealth* and *property wealth* are measured in thousand year-2000 DKK.

Table 2. Characteristics of houses sold, 1992–2010

	All	Forced sales		Difference
		Yes (1)	No (2)	(1)-(2)
	Panel A: House characteristic			
Interior size (m2)	128.2	117.4	128.2	-10.8***
	(123.0)	(113.0)	(123.0)	[-20.89]
Lot size (m2)	879.3	854.6	879.5	-24.9***
	(788.0)	(787.0)	(789.0)	[-2.98]
House age (years)	50.9	54.3	50.9	3.4***
	(40.0)	(44.0)	(40.0)	[7.22]
Bathrooms (#)	1.24	1.10	1.24	-0.15***
	(1.00)	(1.00)	(1.00)	[-18.90]
Basement (%)	33.6	37.4	33.6	3.8***
	(0.0)	(0.0)	(0.0)	[6.44]
Basement size (m2)	31.5	36.6	31.5	5.1***
	(0.0)	(0.0)	(0.0)	[2.86]
	Panel B: House prices and assessed house value (DKK 1,000)			
House price (1)	1091.8	959.5	1092.7	-133.2***
	(850.0)	(737.7)	(850.0)	[-11.2]
Assessed house value (2)	1125.8	1099.3	1126.0	-26.7**
	(893.9)	(846.7)	(894.3)	[-2.11]
Estimated discount (2)-(1)	34.1	139.8	33.3	106.5***
	(42.3)	(109.0)	(41.8)	[15.9]
N	877,559	6,329	871,230	

Note: We report mean (and median) house characteristics for all house sales, and sales that are classified as forced or not, respectively. Forced sales result from sudden deaths of the owner of the house. Panel A reports house characteristics: *Interior size*, *lot size* and *basement size* are measured in square meters, *house age* is measured in years, *bathroom* is a count variable, and *basement* is an indicator variable. Panel B reports the average *house price* and the *assessed house value* from the Danish tax authorities prior to the sale. *Estimated discount* is the difference between the assessed house value and the realized house price. T-statistics are in square brackets. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Table 3. Forced sales and house prices

Dependent variable	**Log. house price**			
Sample	**All**	**All**	**All**	**All**
	(1)	**(2)**	**(3)**	**(4)**
Forced sale	-0.0681***	-0.0935***	-0.0508**	
	(0.0054)	(0.0049)	(0.0073)	
Forced sale * Months after death			-0.0067***	
			(0.0008)	
Forced sale after 0 to 90 days				-0.0338***
				(0.0092)
Forced sale after 91 to 180 days				-0.0847***
				(0.0086)
Forced sale after 181 to 270 days				-0.1356***
				(0.0117)
Forced sale after 271 days or more				-0.1510***
				(0.0106)
Log of assessed house value		0.0495***	0.0495***	0.0495***
		(0.0001)	(0.0001)	(0.0001)
House characteristics	Yes	Yes	Yes	Yes
Calendar month effects	Yes	Yes	Yes	Yes
Location-year effects	Yes, fixed	Yes, fixed	Yes, fixed	Yes, fixed
N	877,559	877,559	877,559	877,559

Note: The dependent variable is the log of the house price. *Forced sale* is an indicator for forced sales due to sudden death. *Months after death* measures the difference between the time of death and the time of sales, and is measured in months. *Forced sale after 0 to 90 days* is an indicator for whether the forced sale occurred 0 to 90 days after the sudden death. *Forced sale after 91 to 180 days* is an indicator for whether the forced sale occurred 91 to 180 days after the sudden death. *Forced sale after 181 to 270 days* is an indicator for whether the forced sale occurred 181 to 270 days after the sudden death. *Forced sale after 271 days or more* is an indicator for whether the forced sale occurred 271 days or more after the sudden death. House characteristics are described in Table 2 and include; log. of assessed house value, Interior size, lot size, basement size, house age, bathroom and basement. Full table with all house characteristics are presented in the online Appendix D. Standard errors are reported in parentheses. ***, **, and * denote significance at the 1, 5, and 10 percent levels, respectively.

Table 4. Market conditions and the forced sale discount

Dependent variable	Log. house price					
	(1)	(2)	(3)	(4)	(5)	(6)
Forced sale	-0.0982***	-0.0868***	-0.0899***	-0.1032***	-0.1058***	-0.1357***
	(0.0057)	(0.0053)	(0.0072)	(0.0067)	(0.0069)	(0.0165)
Forced sale x Boom	0.0188*		0.0105			
	(0.0113)		(0.0117)			
Forced sale x Bust		-0.0440***	-0.0409***			
		(0.0138)	(0.0142)			
Forced sale x House price growth				0.1382**		
				(0.0658)		
Forced sale x Local market activity					0.0030***	
					(0.0012)	
Forced sale x Local market turnover						0.0127***
						(0.0047)
House characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Calendar month effects	Yes	Yes	Yes	Yes	Yes	Yes
Location-year effects	Yes, fixed	Yes, fixed	Yes, fixed	Yes, fixed	Yes, fixed	Yes, fixed
N	877,559	877,559	877,559	877,559	877,559	877,559

Note: The dependent variable is the log. of the house price. *Forced sale* is an indicator for forced sales due to sudden death. *Boom* is an indicator for years in which house prices increased by 10.0% or more. *Bust* is an indicator for years having declining house prices. *House price growth* measures the growth in house prices in the current year in percentage points. *Local market activity* counts the number of house sales in each municipality in each year divided by 100. *Local market turnover* measures the fraction of houses that are sold in each municipality in each year. House characteristics are described in Table 2 and include; Log of assessed house value, Interior size, lot size, basement size, house age, bathroom and basement. Standard errors are reported in parentheses. ***, **, and * denote significance at the 1, 5, and 10 percent levels, respectively.

Table 5. Financial constraints and the forced sale discount

Dependent variable	Log. house price		
	(1)	(2)	(3)
Forced sale	-0.0779***	-0.0835***	-0.0719***
	(0.0062)	(0.0063)	(0.0068)
Forced sale by financially constrained owner	-0.0659***		-0.0647***
	(0.0141)		(0.0142)
Forced sale by financially constrained beneficiaries		-0.0297***	-0.0272***
		(0.0132)	(0.0132)
House characteristics	Yes	Yes	Yes
Calendar month effects	Yes	Yes	Yes
Location-year effects	Yes, fixed	Yes, fixed	Yes, fixed
N	687,216	687,216	687,216

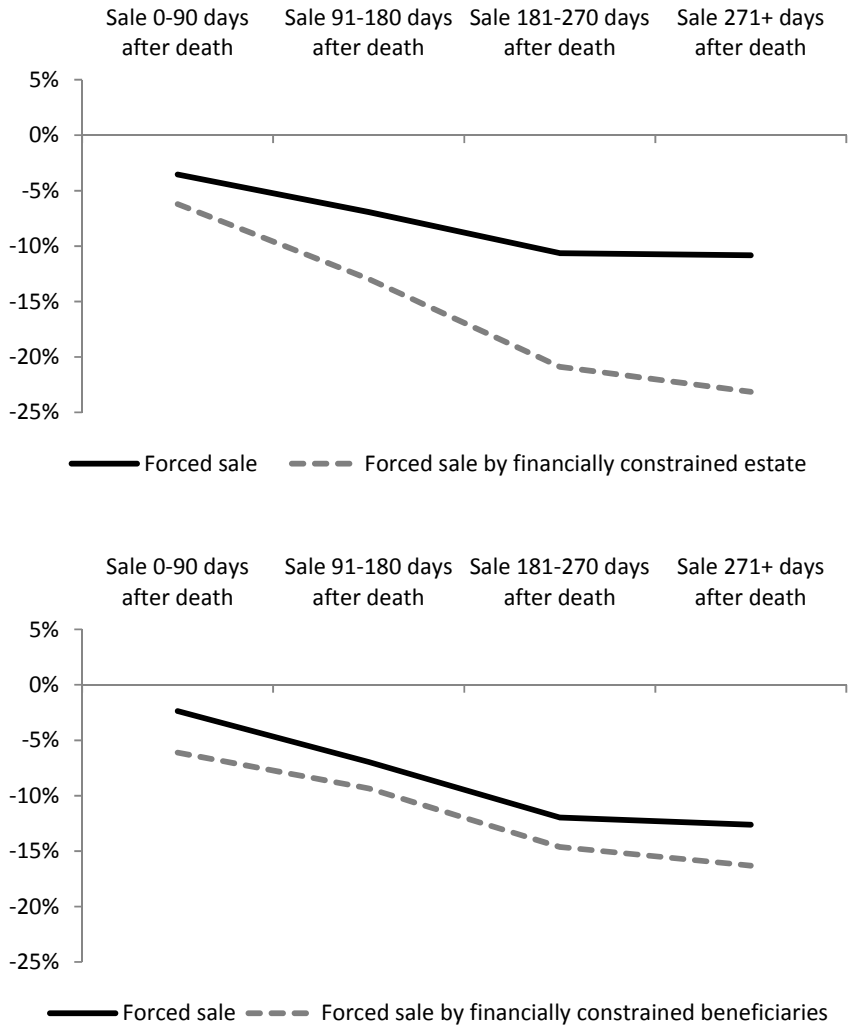
Note: The dependent variable is the log. of the house price. The sample includes all house sales from 1996 to 2010. *Forced sale* is an indicator for forced sales due to sudden death. *Forced sale by financially constrained estate* is an indicator for whether the estate has negative net wealth, excluding house equity. *Forced sale by financially constrained beneficiary* is an indicator for when all beneficiaries have negative net wealth. House characteristics are described in Table 2 and include; Log of assessed house value, Interior size, lot size, basement size, house age, bathroom and basement. Standard errors are in parentheses. ***, **, and * denote significance at the 1, 5, and 10 percent levels, respectively.

Table 6. Alternative specifications

Dependent variable	**Log. house price**				
Model	**Hedonic model**		**Propensity score matching**		**Hedonic model**
Forced sales sample	**Traffic accidents**		**All**	**House age ≤ 15**	**Tenancies**
	(1)	**(2)**	**(3)**	**(4)**	**(5)**
Forced sale	-0.1262***		-0.0640***	-0.1003*	-0.0609*
	(0.0260)		(0.0098)	(0.0591)	(0.0366)
Forced sale after 0-90 days		0.0367			
		(0.0526)			
Forced sale after 91-180 days		-0.0772*			
		(0.0437)			
Forced sale after 181-270 days		-0.2093***			
		(0.0660)			
Forced sales after 271 days or more		-0.3073***			
		(0.0526)			
House characteristics	Yes	Yes	No	No	Yes
Calendar month effects	Yes	Yes	No	No	Yes
Location-year effects	Yes, fixed	Yes, fixed	No	No	Yes, fixed
N	871,455	871,455	669,374	57,879	61,200

Note: The dependent variable is the log. of the house price. Columns 1 and 2 restrict forced sales to traffic accidents. Columns 3 and 4 use a propensity score matching method using exact matching on municipality and year of sale, house age, and interior size vigintiles. The propensity score is calculated by the age of the seller (deceased for treated). Column 5 restricts the sample to houses with tenancies. *Forced sale* is an indicator for whether the property sale is forced due to sudden death. *Forced sale after 0 to 90 days* is an indicator for whether the forced sale occurred 0 to 90 days after the sudden death. *Forced sale after 91 to 180 days* is an indicator for whether the forced sale occurred 91 to 180 days after the sudden death. *Forced sale after 181 to 270 days* is an indicator for whether the forced sale occurred 181 to 270 days after the sudden death. *Forced sale after 271 days or more* is an indicator for whether the forced sale occurred 271 days after the sudden death. House characteristics are described in Table 2 and include; Log of assessed house value, Interior size, lot size, basement size, house age, bathroom and basement. Standard errors are reported in parentheses. ***, **, and * denote significance at the 1, 5, and 10 percent levels, respectively.

Figure 1. Financial constraints and the time pattern of forced sale discount



Note: This figure reports the time pattern of forced sale discount using our hedonic pricing model. *Forced sale* is an indicator for forced sales due to sudden death. *Forced sale by financially constrained estate* is an indicator for whether the estate has negative net wealth, excluding house equity. *Forced sale by financially constrained beneficiary* is an indicator for when all beneficiaries have negative net wealth.