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Round-Number Effects in Real Estate Prices: Evidence from Germany

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Abstract

Round numbers affect behavior in various domains, e.g., as prominent thresholds or focal points in bargaining. In line with earlier findings, residential real estate transactions in Germany cluster at round-number prices, but there are also interesting (presumably cultural) differences. We extend our analysis to the commercial real estate market, where stakes are even higher and market participants arguably more experienced. For the same type of object, professionals cluster significantly less on round-number prices compared to non-professionals. We employ machine learning and show that transactions of family homes and condominiums at round-number prices are 2–7% above their hedonic values.

Keywords: round-number effects, focal points, residential real estate, commercial real estate, housing prices, machine learning.

JEL Codes: D01, D91, C78, R31.

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1 Introduction

Motivation Decision-makers seem to have a bias in favor of "round numbers," and such behavior has been documented in a wide variety of contexts. For example, Allen, Dechow, Pope, and Wu (2017) show that runners aim to stay below round-number finishing times, for example, aiming to run a marathon in under four hours. In a similar vein, it appears that decision-makers strive to surpass round-number thresholds in performance scales (see e.g., Pope and Simonsohn, 2011, for the cases of professional baseball players' batting averages, high school students' SAT scores, and related lab settings). The influence of round numbers extends to settings in which there are substantial financial stakes. For example, in used-car transactions, there are discrete drops in sales prices at 10,000-mile odometer thresholds (see e.g., Lacetera, Pope, and Sydnor, 2012; Busse, Lacetera, Pope, Silva-Risso, and Sydnor, 2013) and, for vintage cars, at thresholds relating to the car's year of first registration (see e.g., Englmaier, Schmöller, and Stowasser, 2017b, for the case of Germany). Converse and Dennis (2018) also find that, in US stock markets, round-number trade volumes occur more frequently than one would expect.[1]

Even where the stakes are high, round numbers affect behavior. This is illustrated by Pope, Pope, and Sydnor (2015) in their study of the US residential real estate market. The authors find that a large share of transactions takes place at round-number prices, such as prices evenly divisible by 5,000, 25,000, and 50,000. Meng (2023) and Best and Kleven (2018) provide similar evidence for real estate transactions in the UK. While some round-number effects might be driven by behavioral biases (for example, consider the apparent desire to finish a marathon in under four hours), Pope, Pope, and Sydnor (2015) convincingly argue that, in the context of real estate transactions, round-number prices serve as focal points (in the sense of Schelling, 1960) in the negotiations between buyers and sellers. In particular, for part of their sample, Pope, Pope, and Sydnor (2015) have access not only to transaction prices, but also to listing prices. They find that objects that sell at round-number prices rarely have round number listing prices,[2] implying that the special attraction of round-number prices particularly

[1] More broadly, it has been shown that the salience of certain features of an economic problem affects decision-making, see e.g., Englmaier, Roider, and Sunde (2017a) for the reaction of workers to incentive provision in firms, Karlan, McConnell, Sendhil, and Zinman (2016) for savings decisions, Stango and Zinman (2014) for the likelihood of incurring checking overdraft fees, Brown, Hossain, and Morgan (2010) and Hossain and Morgan (2006) for bidding in online auctions, and Chetty, Looney, and Kroft (2009) for retail sales.

[2] Listing prices are often "charm prices" (i.e., prices that are just below some prominent threshold, such as

emerges in the negotiations, where they arguably serve as particularly prominent focal points.[3]

For most individuals, buying a home will be among the most high stakes decisions of their lifetime. At the same time, transactions like these are generally rare, making it hard to acquire relevant experience. This is particularly true for the German residential real estate market. For example, Kaas, Kocharkov, Preugschat, and Siassi (2021) show that Germany has both the lowest homeownership rate in the developed world and a very low turnover rate for houses and condominiums (averaging at about half that of other Western European countries).

A lack of transactional experience in such markets might affect the appeal of round numbers as focal points in negotiations. For that reason, the following questions emerge. First, it would be interesting to consider commercial real estate transactions (where market participants interact frequently) to explore the importance of round-number prices when market participants are experienced. Second, it might be instructive to directly compare the relevance of round-number prices in settings where some transactions are conducted by "professionals" and others by "non-professionals". Finally, given the important role of round-number prices in real estate markets, it seems worthwhile to explore the degree to which the appeal of round numbers affects price formation. Our paper makes a contribution to answering these questions.

Contribution to the Literature We have access to a data set containing 5.38 million real estate transactions in Germany in the period 2003 to 2022, covering various types of residential and commercial properties. This constitutes approximately 30% of all real estate transactions in Germany in this time interval. The data provide information on each object's final sales price and a number of additional characteristics.

We obtain the following findings. First, we show that Pope, Pope, and Sydnor's (2015) main results on residential real estate can be extended to the case of Germany, with an interesting difference. In the German data, there is no pronounced clustering of transactions at prices that are evenly divisible by 25,000, which might be driven by the fact that (culturally) "quarters" play a less pronounced role in Germany than in the US.

$499,000). For family homes in the fourteen largest metropolitan statistical areas in the U.S., Chava and Yao (2017) find that 40% of all listing prices end with 900, while 45% are evenly divisible by 1,000. For final sales prices, these fractions are 9% and 70%, respectively. See Repetto and Solís (2020) for evidence on the Swedish housing market. Hofmann and Stowasser (2023) document the presence of charm pricing in rental markets. For a survey of behavioral phenomena in real estate markets, see e.g., Salzmann and Zwinkels (2017).

[3]For experimental evidence on the relevance of focal points in bargaining, see e.g., Isoni, Poulsen, Sugden, and Tsutsui (2013, 2014).

Second, we find that also in commercial real estate markets (where market participants are arguably more experienced and interact more frequently, and stakes are relatively high) there is strong evidence of clustering at round-number prices.

Third, in order to assess the relative importance of round-number effects in residential and commercial real estate transactions, we hold the type of object fixed. We look at the sales of condominiums, where some are acquired to be occupied by the buyer (which we interpret as a residential motive) and others that are acquired to be let to third parties (which we interpret as a commercial motive). We document that, in commercial transactions, a significantly smaller fraction of sales takes place at round-number prices. In particular, relative to residential transactions, the fraction of commercial transactions that happen at round-number prices is about a third lower. Nevertheless, a substantial fraction of commercial transactions still involves round-number prices. Thereby, we contribute to the literature on differences in decision-making by what we term "non-professionals" (who do a task only infrequently) and more experienced "professionals".[4] In this respect, Converse and Dennis (2018) and Busse, Lacetera, Pope, Silva-Risso, and Sydnor (2013), discussed above, are the studies most closely related to our own. In particular, Converse and Dennis (2018) find that, in stock trades, round-number trade volumes occur less frequently "with higher investor sophistication" (proxied by the share of institutional ownership in the company under consideration). For used car sales, Busse, Lacetera, Pope, Silva-Risso, and Sydnor (2013) show that price discontinuities at round-number odometer thresholds are smaller for wholesale than for retail transactions. We extend these findings to the case of high-stakes real estate transactions.

Finally, we explore the degree to which the appeal of round numbers affects price formation. We do so by fitting hedonic models for objects that sell at round-number prices and using the parameter estimates obtained to predict the prices of objects that sell at round-number prices. We use the difference between predicted and actual round number sales prices as a measure of the price distortion from the appeal of round numbers. We conduct this exercise for sales of family homes and condominiums, for which we have the most comprehensive set of covariates. If, instead of OLS, we use regression trees to estimate the hedonic models (which improves the fit considerably), we find that for transactions that take place at round-number prices, on

[4]When looking at behavioral biases, this literature finds that experience that is closely related to the task at hand reduces or even eliminates such effects. For a survey, see e.g., Fréchette (2016).

average, the actual price is between two and seven percent larger than its predicted value, i.e., these objects are sold at a premium. Notably, as argued by Meng (2023), such an appeal of round numbers might also affect *future* prices. In particular, Meng (2023) considers repeated real estate transactions in the Greater London area. She documents that if the previous sales price is a round number, the subsequent sales price at a *later* sale is on average 4% higher compared to objects where the previous sales price was a charm price, which seems to be driven by reference-dependent preferences.

Outline The remainder of the paper is structured as follows. In Section 2, we introduce the institutional background and the data. In Section 3, we present our evidence on the special appeal of round-number prices in residential and commercial real estate, and Section 4 turns to the relative importance of the effect in these real estate categories. In Section 5, we turn to the question of how the special appeal of round numbers affects sales prices relative to predicted values based on object characteristics. Section 6 concludes. Additional figures and tables can be found in an Appendix.

2 Institutional Background and Data

Our analysis is based on a proprietary dataset of more than 5.38 million residential and commercial real estate transactions in Germany between January 1, 2003 and December 31, 2022. As such, our data cover approximately 30% of all real estate transactions in Germany in the period. We were granted access to this data by *vdp research GmbH*, which is the real estate research institute of the *Association of German Pfandbrief Banks ("Verband deutscher Pfandbriefbanken")*. Nearly 600 regional and national member banks report on the real estate transactions that they finance to *vdp research GmbH*.[5]

Table 1 provides descriptive statistics for our data. This shows that transactions related to residential real estate (i.e., family homes and owner-occupied condominiums) comprise 60% of all transactions. The average family home in our sample sold for slightly more than 320,000 Euro, while the average owner-occupied condominium sold for just above 223,000 Euro. Apartment buildings, the largest category in commercial real estate, occupy a share of about 26

[5]In Germany, approximately 90% of all real estate transactions are credit-financed, and according to confidential analysis by *vdp research GmbH* their sample is representative of real estate transactions in Germany. *vdp research GmbH* mainly uses this data for providing various price indices and for consulting purposes.

Table 1: Descriptive Statistics of Sales Prices by Type of Real Estate

No.	Type of Real Estate	Observations	Mean	10^{th} Percentile	Median	90^{th} Percentile
Residential Real Estate		3,240,578	276,801	86,000	222,000	490,000
(1)	Family Homes (Detached)	1,274,934	322,083	125,000	269,000	546,000
(2)	Family Homes (Other)	513,890	315,627	130,000	261,000	537,000
(3)	Condominiums (Owner-Occupied)	1,451,754	223,290	66,000	165,103	400,000
Commercial Real Estate		2,149,232	6,236,457	139,000	500,000	6,500,000
(4)	Condominiums (Let)	132,914	258,329	53,648	130,445	410,000
(5)	Apartment Buildings	1,420,926	1,596,409	165,000	450,000	2,300,000
(6)	Commercial Building Land	2,181	12,200,000	230,000	1,200,000	11,300,000
(7)	Office Buildings	153,377	44,000,000	745,000	8,500,000	102,000,000
(8)	Retail Properties (Small)	62,507	9,059,730	176,000	1,309,115	8,895,000
(9)	Retail Properties (Large)	49,255	29,800,000	1,200,000	6,820,000	66,500,000
(10)	Shopping Malls	15,011	45,500,000	1,560,000	12,100,000	152,000,000
(11)	Warehouses	177,643	4,053,747	74,000	385,000	7,510,000
(12)	Factory Buildings	62,268	6,290,115	255,000	1,200,000	10,900,000
(13)	Hotels (Business)	35,400	5,902,074	332,000	1,394,000	12,300,000
(14)	Hotels (Leisure)	31,358	837,451	125,100	395,000	1,378,000
(15)	Hotels (Other)	6,392	41,000,000	380,000	10,600,000	113,000,000

Note: Sales prices are nominal and denoted in Euro. The category "Retail Properties (Small)" ("Retail Properties (Large)") is comprised of outlets with a sales floor of up to (more than) 800 square meters. "Residential Real Estate" consists of categories (1)-(3), while "Commercial Real Estate" consists of categories (4)-(15).

percent, although commercial real estate includes a wide range of other categories. The data include the transaction price and date of sale of each object. For residential transactions in particular, we have access to additional characteristics of the respective property, discussed in greater detail in Section 5.

3 Evidence on Round-Number Effects in Sales Prices

In this section, we replicate the analysis in Pope, Pope, and Sydnor (2015) for residential real estate in Germany and extend it to the case of commercial real estate. We also investigate whether round-number prices play a bigger role in residential or commercial transactions.

3.1 Residential Real Estate Transactions

As discussed above, Pope, Pope, and Sydnor (2015) find that round-number prices serve as focal points in residential real estate transactions in the US. As it turns out, there are also strong round-number effects in the case of Germany. However, there are also interesting differences with respect to the specific prices at which clustering occurs, which might be culturally driven.

In a first step, we illustrate our findings graphically. Panels (a) and (b) of Figure 1 display histograms of residential real estate transactions across sales prices for two exemplary price ranges.[6] In both panels, there is a clear clustering of transactions at prices that are evenly divisible by 5,000 (as indicated by the dotted vertical lines). These spikes tend to be more pronounced if the respective price is a multiple of 10,000, 50,000, or even 100,000. Interestingly, and in stark contrast to Pope, Pope, and Sydnor's (2015) findings for the US, in Germany, there do not seem to be strongly pronounced clusters at prices that are evenly divisible by 25,000. Intuitively, this might be because, for historical reasons, the "quarter" unit is much more commonly used as a measure in the US than in Germany. For example, there is a quarter dollar coin in the US, while no such partition exists in the Euro. Hence, multiples of 25,000 might be more prominent numbers in the US than in Germany and are thus more likely to serve as salient focal points. This is consistent with findings from social psychology documenting that the salience of certain numbers is influenced by cultural factors (see e.g., Converse and Dennis, 2018).

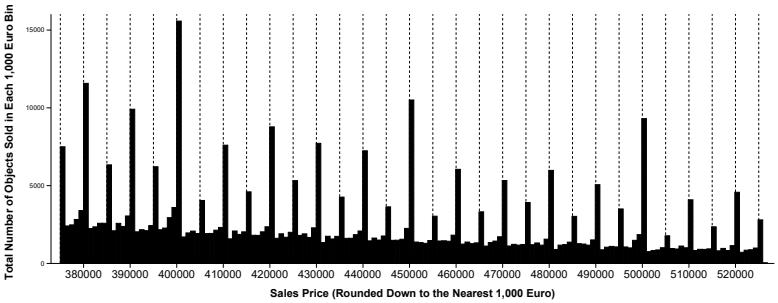
In our second step, we investigate the statistical significance of these findings through a regression analysis that is based on the specification by Pope, Pope, and Sydnor (2015).[7] In particular, we regress the number of sales at a given price on a set of dummy variables that indicate if the respective price is a "round" number. To this end, we define dummy variables *D5000*, *D10000*, *D25000*, and *D50000* that are equal to 1 if the given sales price is evenly divisible by 5,000, 10,000, 25,000, and 50,000, respectively, and 0 otherwise. Note that these indicators are not defined exclusively. For example, for a sales price of 400,000 Euro all the dummy variables would take the value of 1. Hence, adding up the coefficients on all dummy variables gives the overall effect of being a round number on the number of sales at this price.

[6] For reasons of comparability, we consider the same price ranges as depicted in Figures 5 and 6 of Pope, Pope, and Sydnor (2015), where in the present case, prices are in Euro.

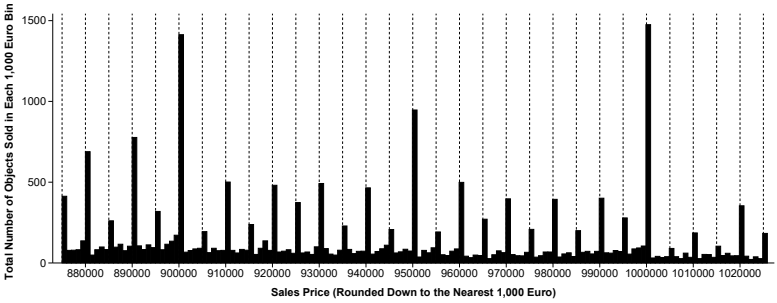
[7] As Pope, Pope, and Sydnor (2015), we restrict attention to observations where sales prices are evenly divisible by 1,000.

Figure 1: Number of Transactions Across Sales Prices

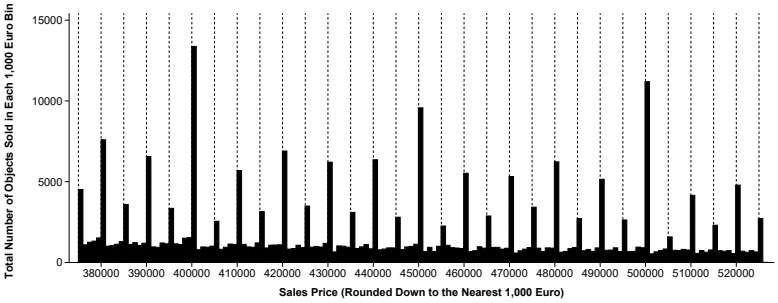
(a) Residential Real Estate (Price Range: 375,000 - 525,000 Euro)



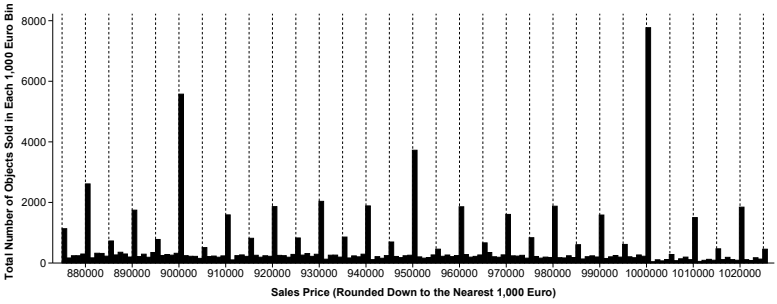
(b) Residential Real Estate (Price Range: 875,000 - 1,025,000 Euro)



(c) Commercial Real Estate (Price Range: 375,000 - 525,000 Euro)



(d) Commercial Real Estate (Price Range: 875,000 - 1,025,000 Euro)



Note: The figure displays the number of transactions across sales prices. Panels (a) and (b) focus on residential real estate transactions, while Panels (c) and (d) focus on commercial real estate transactions. Panels (a) and (c) ((b) and (d)) consider objects whose sales prices were between 375,000 and 525,000 Euro (875,000 and 1,025,000 Euro). In the figure, sales prices are rounded down to the next 1,000 Euro. For example, a value of "400,000" includes all transactions within the price range of 400,000-400,999 Euro. For our definitions of residential real estate and commercial real estate, see Table 1.

We control for the overall distributional shape of sales prices by following Pope, Pope, and Sydnor (2015) and by including the seventh-order polynomial of the respective sales price in the regressions. Finally, there may be a concern that, for very high sales prices, almost all transactions might take place at round prices. For example, this could be driven by the fact that in "the relatively high" price ranges, 50,000 Euro might seem the natural increment for price variations. For this reason, in the main analysis, we restrict attention to transactions with sales prices weakly below 1,025,000 Euro, which also serves as the upper bound in Figure 1.[8] The results discussed in the following are robust and do not depend on this restriction (see Section 3.3 below).

The results of these regressions are reported in Table 2. In particular, Column (1) corresponds to the main specification in Pope, Pope, and Sydnor (2015), and it confirms the findings depicted in Figure 1, Panels (a) and (b). There are significant increases in the number of transactions at sales prices that are multiples of 5,000 and 50,000. However, there is no additional effect for sales prices that are multiples of 25,000. Hence, market participants do not seem to behave differently at these prices compared to other 5,000-multiples. Rather, Column (2) supports the visual impression from Figure 1, and there are significant spikes at prices evenly divisible by 10,000. For this reason, in all subsequent regressions, we additionally include *D10000* as an explanatory variable.

In the next step, as set out in Column (3) of Table 2, we investigate whether round-number prices "pull mass", i.e., whether they attract transactions that would otherwise occur at prices slightly lower or slightly higher than the round-number price under consideration. As such, we focus on sales prices that are multiples of 50,000, and we define two additional dummy variables. In line with Pope, Pope, and Sydnor (2015), *Dbelow50000* (*Dabove50000*) is equal to 1 if the respective sales price is at least 2,000 Euro but at most 7,000 Euro below (above) a price divisible by 50,000, and 0 otherwise. Analogous to Pope, Pope, and Sydnor (2015), Column (3) reveals that the findings on the special appeal of round-number prices are robust. At the same time, the coefficients on *Dabove50000* and *Dbelow50000* are negative, but not statistically significant. They are also not jointly significant according to an F-test.[9]

[8] Recall from Table 1 that the 90th percentile of sales prices in residential real estate transactions is 490,000.

[9] The insignificance of the *Dbelow50000* dummy might be driven by "charm prices", i.e., prices that are just below some prominent threshold (such as a round-number price) pulling mass in their own right. This is a pattern that seems to be visible in Figure 1. A left-digit bias on the part of buyers might foster sales at such prices (see e.g., Meng, 2023; List, Muir, Pope, and Sun, 2023, for recent evidence on the power of charm pricing).

Table 2: Regression Analysis of the Number of Transactions Across Sales Prices

	Residential Real Estate			Commercial Real Estate	
	(1)	(2)	(3)	(4)	(5)
D5000	4414.52***	2992.13***	3009.45***	1430.67***	1438.67***
	(195.60)	(256.55)	(260.16)	(87.46)	(88.66)
D10000		2844.78***	2810.15***	2382.67***	2366.67***
		(345.94)	(356.24)	(117.93)	(121.40)
D25000	-637.34	785.65	751.15	578.21***	562.28***
	(530.26)	(542.02)	(548.87)	(184.78)	(187.04)
D50000	5732.07***	2886.88***	2921.76***	3212.02***	3228.21***
	(714.73)	(773.98)	(779.11)	(263.86)	(265.50)
Dabove50000			-132.18		-76.53
			(217.74)		(74.20)
Dbelow50000			-3.40		14.63
			(221.96)		(75.64)
7th Order Price Polynomial	yes	yes	yes	yes	yes
Adjusted R-Squared	0.69	0.71	0.71	0.83	0.82
Observations	1025	1025	1025	1025	1025

Note: This table reports OLS regressions. The dependent variable is the number of transactions at a given sales price, where the analysis is restricted to sales prices that are evenly divisible by 1,000 and that are weakly below 1,025,000 Euro. Standard errors are given in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

We gauge the economic significance of the round-number effects documented in Table 2 by considering the example of a sales price of 400,000 Euro. When neglecting the round-number dummy variables, Column (2) predicts 1,617 sales at this price, where this number is calculated by using the (unreported) coefficients on all the other right-hand side variables. However, as 400,000 is evenly divisible by 50,000, 25,000, 10,000, and 5,000, Column (2) predicts 9,510 additional sales (i.e., $2,887 + 786 + 2,845 + 2,992$) at this price, constituting a 588% increase.

To summarize, our analysis in Section 3.1 extends Pope, Pope, and Syndor's (2015) findings on residential real estate transactions to the case of Germany. One notable exception is the lack of clustering on prices that are multiples of 25,000, consistent with quarters being less of a relevant metric in Germany.

The insignificance of the *Dabove50000* dummy might be driven by the conditions prevailing in the market in Germany in the period under consideration, which might be characterized as a seller's market. As illustrated by Figure 4 in the Appendix, prices for residential real estate steadily increased in Germany from 2003 to 2022. Moreover, our data contain annual, county-level vacancy rates for housing units for the period 2010-2020. This reveals a rather low average vacancy rate of 3.81% but also very little variation; the standard deviation is 1.72, and the 90th percentile is 5.53. Given these observations, the pull factor of round (but lower) prices (which are less favorable for sellers) might have been reduced.

3.2 Commercial Real Estate Transactions

In this section, we investigate whether round-number effects also play a role in commercial real estate transactions, where market participants are arguably different and where transaction values can be substantially higher than in residential real estate transactions (see Table 1).

As discussed in the Introduction, task frequency and stake size might influence behavior. Hence, it could be that professional market participants who frequently engage in commercial real estate transactions rely less heavily on round-number prices as focal points in negotiations (because, for example, they have a clearer, more precise grasp of the value of an object).[10] Hence, whether round-number effects also play a role in commercial real estate transactions is an empirical question and does not immediately follow from the findings of Section 3.1.

However, Panels (c) and (d) of Figure 1 clearly illustrate that, also for the case of commercial real estate, transactions are clustered at sales prices that are multiples of 5,000, 10,000, and 50,000. Multiples of 25,000 do not create particularly pronounced spikes. These observations are confirmed in the regression analysis reported in Table 2. There, Columns (4) and (5) qualitatively yield the same results as Columns (2) and (3). The only difference is that the *D25000* dummy is now significant, but relative to the other dummies its effect is small. Similar to the discussion of the case of residential real estate, consider a sales price of 400,000 Euro. When neglecting the dummy variables, Table 2, Column (4), would predict 1,294 sales at this price. However, because 400,000 is evenly divisible by 50,000, 25,000, 10,000, and 5,000, Column (4) suggests 7,604 additional sales (i.e., $3,212 + 578 + 2,383 + 1,431$), which would constitute an increase by 588% (which is the same percentage value that was obtained in the case of residential real estate).

3.3 Robustness

Tables 6 and 7 in the Appendix replicate the analysis reported in (main) Table 2 for all prices weakly below 2,300,000 Euro and for all prices, respectively. Both tables qualitatively confirm the main findings. As an illustration, see Figure 5, which replicates Figure 1 for higher price ranges. One might in principle worry that new objects are constructed to have a round-number

[10] Also, given their greater experience and the higher stakes, it could well be that professional market participants are less prone to a behavioral round-number bias. High-stakes commercial real estate transactions might also involve negotiating teams, and there is evidence that, compared to individuals, teams are less prone to some behavioral biases. For a survey of the literature on team decision-making, see e.g., Kugler, Kausel, and Kocher (2012).

value. We have thus also examined the subset of transactions of objects that, at the time of sale, were more than ten years old. Qualitatively, this analysis yields the same results as those reported in Table 2.

4 Residential and Commercial Real Estate Transactions: Relative Importance of Round-Number Effects

Given that, in Section 3, we have established that, both in residential and commercial real estate transactions, substantial round-number effects are present, the question arises in which of these market segments this phenomenon is more prevalent. The back-of-the-envelope calculations in Section 3.1 and 3.2 suggest that, at a sales price of 400,000, the round number effects in residential and commercial real estate transactions are equally strong at 588%. An important caveat is that the results of this exercise only hold for this specific sales price. Moreover, this analysis does not take into account that the categories of residential and commercial real estate are comprised of quite different objects, in relation to which behavior might differ.

However, our data allow us to overcome this potential problem and investigate more systematically whether commercial real estate transactions are as prone to round-number effects as residential ones. For two reasons, the approach taken in the present section necessarily differs from that taken in Section 3. First, recall that in Table 2, the dependent variable is the absolute number of transactions at a given sales price. Hence, the finding from Table 1 that there are overall more residential than commercial real estate transactions implies that the coefficients of Columns (2) and (4) of Table 2 are not directly comparable. Second, when comparing the effects of round-number prices in residential and commercial real estate, the shapes of the distributions of transactions across sales prices need to be taken into account. For example, in commercial real estate, transactions concluded at high prices constitute a greater share than in the residential real estate case (see e.g., the median sales prices as reported in Table 1). Arguably, the increments in which transactions at high prices are negotiated are more likely to fall into our round-number definition, and, as a consequence, it would be more likely to observe round-number prices in commercial real estate transactions.

We can get around these issues because our data allow us to compare the role of round-number prices for commercial and non-commercial transactions for the same type of real estate

Table 3: Characteristics of Objects

	Family Homes		Condominiums (Owner-Occupied)		Condominiums (Let)	
	Mean	SD	Mean	SD	Mean	SD
Location	2.87	1.07	2.24	0.62	2.39	0.68
Features	2.82	1.09	2.33	0.55	2.41	0.58
Condition	2.69	1.07	2.16	0.52	2.23	0.59
Marketability	2.71	0.59	2.60	0.58	2.68	0.65
	Mean	90^{th} Percentile	Mean	90^{th} Percentile	Mean	90^{th} Percentile
Living Area (in sqm)	340	226	103	128	109	130
Year of Construction	1982	2016	1982	2018	1966	2009
Lot Size (in sqm)	804	1017				

Note: This table reports on additional characteristics of the objects, which are only available for family homes and condominiums. Prior to a transaction, these objects are assessed by a specifically trained appraiser as mandated in the contract between *vdp research GmbH* and participating banks. On a six-point Likert scale (where 1 denotes "very good" and 6 denotes "disastrous"), these appraisers evaluated the quality of each object's location, features, condition, and marketability. For family homes, information on marketability is only available for a subset of 184,544 out of a total of 1,788,824 transactions. "Living Area (in sqm)" and "Lot Size (in sqm)" are measured in square meters. "Lot Size (in sqm)" denotes the size of the lot on which the respective object is located; this information is available for family homes only. In addition to means, for "Location", "Features", "Condition", and "Marketability" the table reports standard deviations (SD), while for the remaining three variables, it reports 90th percentiles (as in these cases standard deviations are not informative due to outliers).

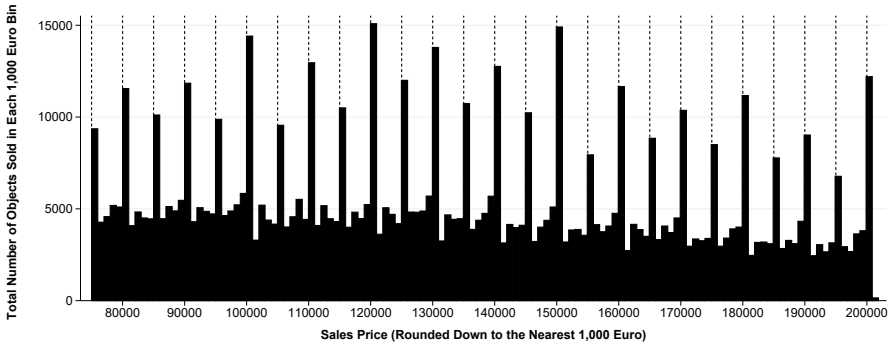
object. Specifically, for the sale of condominiums, we know whether an object is bought to be occupied by the owner (which we label "owner-occupied") or bought to be let (which we label "let"). As a result, our assumption is that buyers who acquire a condominium as an investment (which we interpret as a commercial motive) are presumably more professional and more experienced market participants than buyers who are looking for a home (which we interpret as a residential motive).[11]

The sets of condominiums that are owner-occupied and that are let do not differ substantially with respect to the distributions of their sales prices, where the 10%, 50%, and 90% percentiles are given by 66,000 (53,648), 165,103 (130,445), and 400,000 (410,000) for owner-occupied (let) properties; see Table 1. For family homes and condominiums, we also have data on additional object characteristics; see Table 3. In addition to information on the living area and year of construction, information on quality is included: before its sale, each of these

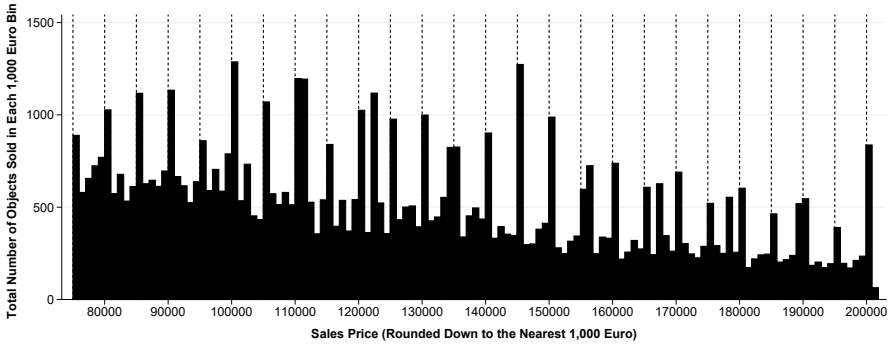
[11]Recall the discussion from the Introduction that, among developed countries, Germany has the lowest howeownership rate and very low turnover rates for houses and condominiums.

Figure 2: Number of Transactions of Condominiums Across Sales Prices

(a) Condominiums: Owner-Occupied



(b) Condominiums: Let



Note: The figure displays the number of transactions of condominiums across sales prices. Panels (a) and (b) focus on objects that are acquired to be occupied by the buyer and objects that are bought to be let, respectively. For illustrative purposes, the price range is restricted to 75,000 - 200,000 Euro. Sales prices are grouped into 1,000 Euro bins (rounded down).

objects is assessed by specifically trained appraisers, who (on six-point Likert scales) evaluate the quality of the property's intra-regional location, features, condition, and marketability.[12] As Table 3 suggests, on average, condominiums that are let are somewhat older, in better condition, and slightly larger (in square meters) than condominiums that are owner-occupied.

Turning to the relative prominence of round-number prices, Figure 2 displays the number of transactions across a range of sales prices of condominiums that are acquired to be occupied by the buyer (Panel (a)) or bought to be let (Panel (b)).[13] Two preliminary observations can be made. First, the number of transactions is substantially higher in Panel (a) than in Panel

[12]This is mandated by the contractual agreement between *vdp research GmbH* and participating banks. For family homes, we also have information on the size of the lot on which the building is located.

[13]For the purpose of illustration, Figure 2 restricts attention to an intermediate range of sales prices between 75,000 and 200,000 Euro (see Table 1).

Table 4: Condominiums: Regression Analysis of Transactions at Round-Number Prices

	Price Evenly Divisible by 5,000			Price Evenly Divisible by 50,000		
	(1)	(2)	(3)	(4)	(5)	(6)
Constant	0.355***	0.297***	0.304***	0.051***	0.028***	0.029***
	(0.000)	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)
Commercial	-0.103***	-0.094***	-0.177***	-0.014***	-0.010***	-0.026***
	(0.001)	(0.001)	(0.003)	(0.001)	(0.001)	(0.001)
Price in 100,000 Euro		0.034***	0.030***		0.014***	0.013***
		(0.000)	(0.001)		(0.000)	(0.000)
Commercial			0.058***			0.011***
× Price in 100,000 Euro			(0.002)			(0.001)
Adjusted R-Squared	0.004	0.008	0.009	0.000	0.004	0.004
Observations	1,429,097	1,429,097	1,429,097	1,429,097	1,429,097	1,429,097

Note: This table reports OLS regressions. The analysis is restricted to observations where the sales price is weakly below 400,000 Euro, which corresponds to the 90th percentile of all condominiums. The dependent variable is an indicator that is equal to 1 if the respective transaction (which is the unit of observation) takes place at a price that is evenly divisible by 5,000 (see Columns (1)-(3)) or evenly divisible by 50,000 (see Columns (4)-(6)), and 0 otherwise. Standard errors are given in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

(b); that is, more condominiums are bought for occupation than to be rented out. Second, comparing the panels suggests that while round-number effects play a role in both categories, they seem to be more pronounced for condominiums where the transaction has a residential motive. That is, in Panel (a) prices that are evenly divisible by 5,000 clearly stick out, while in Panel (b) the picture is less clear-cut.

This is confirmed by a regression analysis; see Table 4. Thereby, the dependent variable is a dummy variable that indicates whether the respective transaction takes place at a round-number price. In particular, this dummy variable is equal to 1 if the respective sales price is evenly divisible by 5,000, and 0 otherwise. That is, in these regressions, the unit of observation is an individual transaction in order to be able to control for the transaction having a commercial or a residential motive.[14] To this end, we define a dummy variable *commercial* that is equal to 1 if the condominium is acquired with the purpose of being let to somebody else, and 0 otherwise. In Table 4, we restrict our attention to transactions that take place at prices that are weakly smaller than the 90th percentile (400,000 Euro) of all transaction prices of condominiums.[15]

[14]Recall that in the regressions of Table 2 the unit of observation were *all* transactions taking place at a given price.

[15]This is meant to eliminate the influence of outliers.

We estimate linear probability models where the dependent variable is regressed on a constant and on the variables *commercial* (see Column (1)), *commercial* and the sales price measured in units of 100,000 Euro (see Column (2)), and *commercial*, the sales price measured in units of 100,000 Euro, and an interaction term (see Column (3)).

Column (1) of Table 4 reveals that 35.5% of the residential transactions take place at a price that is evenly divisible by 5,000. For commercial transactions, this fraction drops significantly to 25.5%; that is round-number prices play a lesser role in these transactions. This finding is confirmed in various robustness checks. Specifically, in Column (2), we additionally control for the sales price. We do this because one could hypothesize that for higher price ranges, it might be more likely that objects are traded at round-number prices simply because the increments by which prices are adjusted in the process of bargaining become larger. The respective coefficient is indeed positive and significant, but the coefficient on *commercial* is basically unaffected.[16] In Column (3), we also include an interaction term of *commercial* and the sales price to investigate whether the differential inclination to trade at round-number prices is more pronounced at higher or lower prices. The positive coefficient on the interaction term implies that it is only at relatively high prices that there are similar shares of residential and commercial transactions at round-number prices. Columns (4)-(6) replicate the analysis of Columns (1)-(3), where the dependent variable is now a dummy that is equal to 1 if the respective sales price is evenly divisible by 50,000, and 0 otherwise. The earlier results are confirmed. For example, Column (4) indicates that 5.1% of the residential transactions are concluded at a price that is evenly divisible by 50,000. For commercial transactions, this drops by about a quarter to 3.8%. To summarize, our analysis of the sales of condominiums suggests that round-number effects play a substantially smaller, but still sizable, role in commercial compared to residential transactions.

5 By How Much Does the Appeal of Round Numbers Affect Prices?

In Section 3, we have documented that many residential and commercial real estate sales are concluded at round-number prices. In the present section, we aim to assess the strength of the "pull" of round numbers in relation to price formation (i.e., we are interested in the difference

[16] Qualitatively the same result obtains when including the seventh polynomial of the price.

between transaction prices and the hedonic values of objects that trade at round-number prices). We conduct this exercise separately for three categories of objects for which our data contain information on objects' characteristics: family homes (i.e., Categories (1) and (2) of Table 1) and the two types of condominiums (owner-occupied and let); see Table 3.[17] We find that, on average, objects that trade at a round-number price are sold at a premium.

We proceed in three steps, each explained in greater detail below. In a first step, we use the information on the characteristics to estimate hedonic values of objects that trade at prices that are not round numbers. Thereby, we rely on OLS regressions (but our results are robust when employing regression trees instead). In the second step, we use the regression coefficients obtained in the first step to predict the hedonic values of objects that trade at round-number prices. In the final step, the residuals from the latter exercise (i.e., the difference between predicted and actual values) give an indication of the "pull" of round-number prices.

For the hedonic regression of the first step, we restrict attention to the "non-round subsample" of the object category under consideration. That is, for the estimation of the regression coefficients, we exclude transactions with sales prices that lie within a neighborhood of 7,000 Euro of prices evenly divisible by 50,000 (where this threshold value is in the spirit of the definition of the neighborhood dummies in Section 3.1). For example, for the round-number price of 350,000 Euro, we exclude all transactions with sales prices in the interval between 343,000 and 357,000 Euro. For this subsample, we regress the log of the sales price on (i) living area (in square meters), (ii) age (i.e., the difference between year of transaction and year of construction), (iii) age squared (to control for well-known non-linear price effects of age), (iv) transaction-year dummies (to control for changes in the price level), (v) county dummies (to control for the object's interregional location), (vi) (intra-regional) location, features, condition, and marketability dummies (see Table 3), (vii) a constant, and (viii) in the case of family homes, we also control for lot size (in square meters).[18] Table 5 reports the number of observations in these regressions; note, in the non-round subsample the average prediction error (i.e., residual) is zero by construction.

[17] Again, to reduce the influence of outliers, we only consider transactions taking place at prices weakly below the respective 90th percentile (see Table 1).

[18] Hence, in the analysis, we restrict attention to observations for which the variable "marketability" is available as this improves the fit of the model substantially. Results are qualitatively unchanged when dropping the variable marketability and using all observations instead. Similarly, using the price level instead of the log of the price yields qualitatively similar results.

Table 5: Average Prediction Errors in the Round-Number Subsamples

	Family Homes	Condominiums (Owner-Occupied)	Condominiums (Let)
Non-Round Subsample			
Number of Observations	99,181	550,124	76,512
R-Squared	0.55 (0.68)	0.38 (0.81)	0.38 (0.79)
Round-Number Subsample			
Number of Observations	7,506	37,585	4,229
Average Prediction Error	0.0806 (0.0698)	0.0910 (0.0205)	0.2228 (0.0670)

Note: In the non-round subsamples, average prediction errors are zero by construction. The entries pertain to the results of OLS regressions. The entries in brackets obtain, when instead of OLS, we employ regression trees (assuming a complexity parameter $cp = 0.00001$). The dependent variable in the regressions is the log of the sales price. When using OLS, we report the adjusted R-squared.

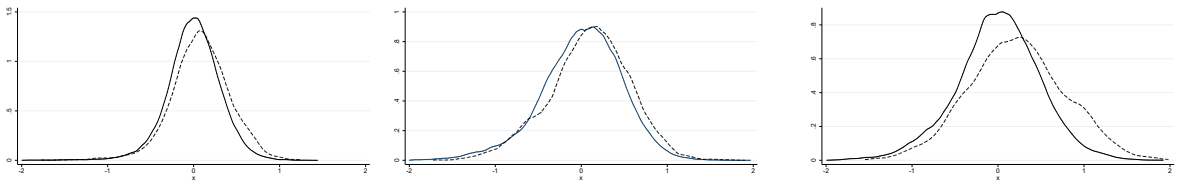
We then use the coefficients obtained from the above regressions in the non-round subsamples to predict prices for the observations in the "round-number subsamples" (i.e., all transactions at prices that are evenly divisible by 50,000); we thus assume that the hedonic contributions of the right-hand side variables are the same in both subsamples.

Figure 3 displays the distributions of the prediction errors (i.e., the differences between actual and predicted values) in the non-round subsample (solid line) and round-number subsample (dotted line). In each of the cases, the average prediction errors in the non-round subsamples are virtually zero, whereas in the round-number subsamples, these are tilted rightwards. In fact, in all three cases the average prediction errors in the round-number subsamples are strictly positive and significantly different from zero (with $p < 0.001$ according to Welch's t-tests), i.e., on average these objects are sold at a premium. For example, family homes in the round-number subsample are, on average, sold at a price that is roughly 8% above the predicted value; see Table 5. For a family home sold at 300,000 Euro, this would imply a premium of about 24,000 Euro.[19] The observation that round-number prices are, on average, higher than their predicted values is consistent with the fact that in the sample period sellers were arguably in a better bargaining position; see the discussion in Footnote 9.

[19]If we use the level of the sales price (instead of its log) as dependent variable, the average prediction error in the round-number subsample is 20,056 Euro ($p < 0.001$, Welch's t-test). The result is also qualitatively robust if the variable "marketability" is dropped from the regression, which substantially increases the number of observations. In this case, the corresponding percentage value is 6.26% ($p < 0.001$, Welch's t-test).

Figure 3: Distributions of the Prediction Errors in the Non-Round Subsample (Solid Line) and the Round-Number Subsample (Dotted Line)

(a) Family Homes (b) Condos (Owner-Occupied) (c) Condos (Let)



6 Conclusion

This paper considers a large sample of the German market to study the role of round-number prices in (high-stakes) real estate transactions. With respect to residential real estate, we show that the findings in Pope, Pope, and Sydnor (2015) for the US can be extended to the German market; there is substantial clustering of transactions at salient round-number prices. We also find pronounced round-number effects in commercial real estate markets, where stakes are even higher and market participants more experienced. When directly comparing the behavior of professionals and non-professionals for the same type of object (i.e., condominiums), it turns out that, compared to non-professionals, the fraction of transactions that professionals settle at round-number prices is significantly lower but still substantial.

In the case of family homes and condominiums (for which additional information on objects' characteristics is available), we obtain evidence that suggests that objects sold at round-number prices trade at a premium of 2-7% relative to their predicted value. That is, the appeal of round numbers seems to have a substantial positive price effect. In principle, this could be driven by the upward trend in Germany's real estate prices in our sample period, which might allow sellers to suggest focal points as basis for a more favorable agreement.

Finally, our analysis documents that what is salient in bargaining (and hence, influences the bargaining outcome) seems to depend on culture. In particular, in Germany, "quarters" (for example in coinage or as a unit of measurement) do not play a particularly prominent role. This seems to be reflected in the finding of a lack of pronounced clustering at prices that are evenly divisible by 25,000 in the German real estate market.

References

Allen, E., P. Dechow, D. Pope, and G. Wu (2017): "Reference Dependent Preferences: Evidence from Marathon Runners," *Management Science*, 63, 1657–1672.

Best, M. C. and H. J. Kleven (2018): "Housing Market Responses to Transaction Taxes: Evidence from Notches and Stimulus in the UK," *Review of Economic Studies*, 85, 157–193.

Brown, J., T. Hossain, and J. Morgan (2010): "Shrouded Attributes and Information Suppression: Evidence from the Field," *Quarterly Journal of Economics*, 125, 859–876.

Busse, M., N. Lacetera, D. Pope, J. Silva-Risso, and J. Sydnor (2013): "Estimating the Effect of Salience in Wholesale and Retail Car Markets," *American Economic Review*, 103, 575–79.

Chava, S. and V. Yao (2017): "Cognitive Reference Points, the Left-Digit Effect, and Clustering in Housing Markets," *mimeo, Georgia State University*.

Chetty, R., A. Looney, and K. Kroft (2009): "Salience and Taxation: Theory and Evidence," *American Economic Review*, 99, 1145–1177.

Converse, B. and P. Dennis (2018): "The Role of "Prominent Numbers" in Open Numerical Judgment: Strained Decision Makers Choose from a Limited Set of Accessible Numbers," *Organizational Behavior and Human Decision Processes*, 147, 94–107.

Englmaier, F., A. Roider, and U. Sunde (2017a): "The Role of Communication of Performance Schemes: Evidence from a Field Experiment," *Management Science*, 63, 4061–4080.

Englmaier, F., A. Schmöller, and T. Stowasser (2017b): "Price Discontinuities in an Online Market for Used Cars," *Management Science*, 64, 2754–2766.

Fréchette, G. R. (2016): "Experimental Economics Across Subject Populations," in *The Handbook of Experimental Economics*, ed. by J. H. Kagel and A. E. Roth, Princeton University Press, vol. 2, 435–480.

Hofmann, M. and T. Stowasser (2023): "Charmers versus Rounders: Rent-Price Discountinuities in the German Housing Market," *mimeo, University of Stirling*.

Hossain, T. and J. Morgan (2006): "...Plus Shipping and Handling: Revenue (Non) Equivalence in Field Experiments on eBay," *B.E. Journal of Economic Analysis and Policy*, 5, 1–30.

Isoni, A., A. Poulsen, R. Sugden, and K. Tsutsui (2013): "Focal Points in Tacit Bargaining Problems: Experimental Evidence," *European Economic Review*, 59, 167–188.

——— (2014): "Efficiency, Equality, and Labeling: An Experimental Investigation of Focal Points in Explicit Bargaining," *American Economic Review*, 104, 3256–87.

Kaas, L., G. Kocharkov, E. Preugschat, and N. Siassi (2021): "Low Homeownership in Germany - A Quantitative Exploration," *Journal of the European Economic Association*, 19, 128–164.

Karlan, D., M. McConnell, M. Sendhil, and J. Zinman (2016): "Getting to the Top of Mind: How Reminders Increase Saving," *Management Science*, 62, 3393–3411.

Kugler, T., E. Kausel, and M. G. Kocher (2012): "Are Groups More Rational Than Individuals? A Review of Interactive Decision Making in Groups," *Wiley Interdisciplinary Reviews: Cognitive Science*, 3, 471–482.

Lacetera, N., D. Pope, and J. Sydnor (2012): "Heuristic Thinking and Limited Attention in the Car Market," *American Economic Review*, 102, 2206–2236.

List, J., I. Muir, D. Pope, and G. Sun (2023): "Left-Digit Bias at Lyft," *Review of Economic Studies*, forthcoming.

Meng, C. (2023): "The Price Paid: Heuristic Thinking and Biased Reference Points in the Housing Market," *Journal of Urban Economics*, 134, 103514.

Pope, D., J. Pope, and J. Sydnor (2015): "Focal Points and Bargaining in Housing Markets," *Games and Economic Behavior*, 93, 89–107.

Pope, D. and U. Simonsohn (2011): "Round Numbers as Goals: Evidence from Baseball, SAT Takers, and the Lab," *Psychological Science*, 22, 71–79.

Repetto, L. and A. Solís (2020): "The Price of Inattention: Evidence from the Swedish Housing Market," *Journal of the European Economic Association*, 18, 3261–3304.

Salzmann, D. and R. Zwinkels (2017): "Behavioral Real Estate," *Journal of Real Estate Literature*, 25, 77–106.

Schelling, T. (1960): *The Strategy of Conflict*, Harvard University Press, Cambridge.

Stango, V. and J. Zinman (2014): "Limited and Varying Consumer Attention: Evidence from Shocks to the Salience of Bank Overdraft Fees," *Review of Financial Studies*, 27, 990–1030.

Appendix

Figure 4: Average Sales Prices of Residential Real Estate Transactions over Time: Family Homes (Dotted Line) and Condominiums (Solid Line)

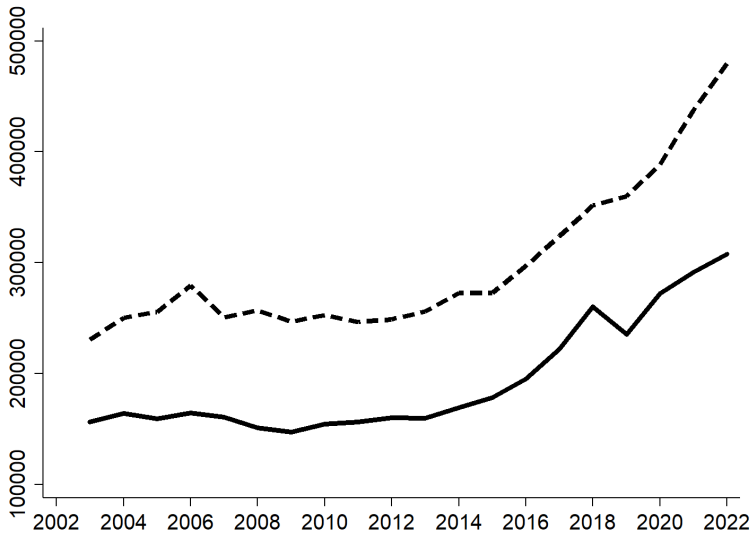


Table 6: Regression Analysis of the Number of Transactions Across Sales Prices (for Sales Prices Weakly Below 2,300,000 Euro)

	Residential Real Estate			Commercial Real Estate	
	(1)	(2)	(3)	(4)	(5)
D5000	2085.25***	1435.82***	1452.60***	704.98***	708.52***
	(113.13)	(150.48)	(152.95)	(56.43)	(57.20)
D10000		1298.86***	1268.00***	1534.32***	1527.24***
		(200.98)	(207.72)	(76.08)	(78.31)
D25000	-261.86	387.57	356.72	321.19***	314.11***
	(304.45)	(317.77)	(322.13)	(120.29)	(121.73)
D50000	2578.03***	1279.16***	1310.17***	2655.80***	2662.96***
	(405.98)	(449.44)	(452.60)	(170.13)	(171.17)
Dabove50000			-127.31		-38.93
			(138.13)		(48.37)
Dbelow50000			3.88		10.60
			(135.26)		(48.37)
7th Order Price Polynomial	Yes	Yes	Yes	Yes	Yes
Adjusted R-Squared	0.62	0.63	0.63	0.72	0.72
Observations	2061	2061	2061	2290	2290

Note: The note below Table 2 applies, except that in the current table all sales prices weakly below 2,300,000 are considered.

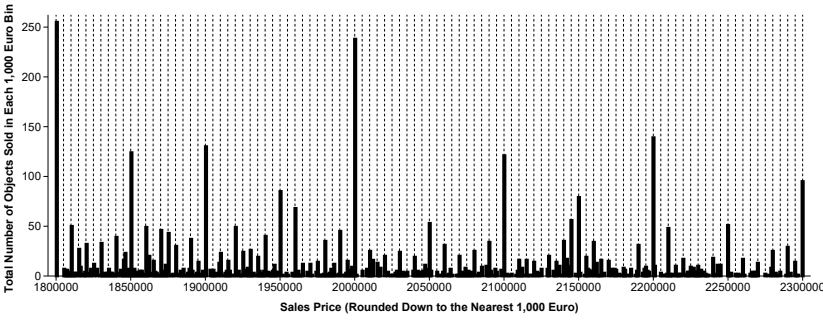
Table 7: Regression Analysis of the Number of Transactions Across Sales Prices (for All Sales Prices)

	Residential Real Estate			Commercial Real Estate	
	(1)	(2)	(3)	(4)	(5)
D5000	1603.66***	1139.26***	1151.22***	218.29***	218.65***
	(111.67)	(155.90)	(158.31)	(27.75)	(28.21)
D10000		794.61***	772.25***	317.10***	316.02***
		(186.71)	(194.76)	(31.00)	(32.70)
D25000	-198.27	279.33	256.12	53.27	52.19
	(301.00)	(320.42)	(325.30)	(52.28)	(53.32)
D50000	1350.21***	609.21	633.79	337.10***	338.19***
	(343.15)	(383.90)	(388.18)	(58.65)	(59.58)
Dabove50000			-132.843		-11.32
			(158.51)		(28.42)
Dbelow50000			25.81		5.49
			(151.06)		(28.15)
7th Order Price Polynomial	yes	yes	yes	yes	yes
Adjusted R-Squared	0.20	0.20	0.20	0.16	0.15
Observations	2924	2924	2924	9095	9095

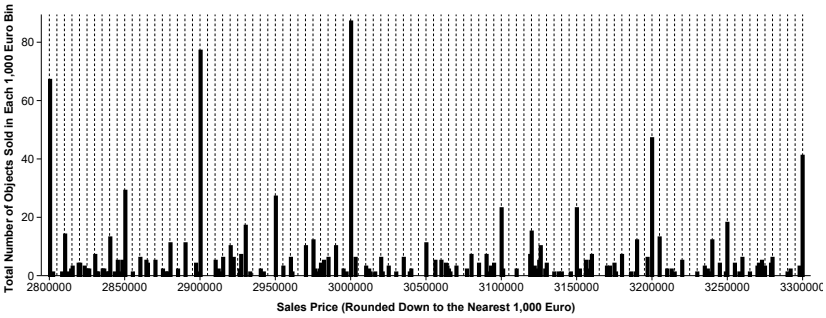
Note: The note below Table 2 applies, except that in the current table all sales prices are considered.

Figure 5: Number of Transactions Across Sales Prices (High Price Ranges)

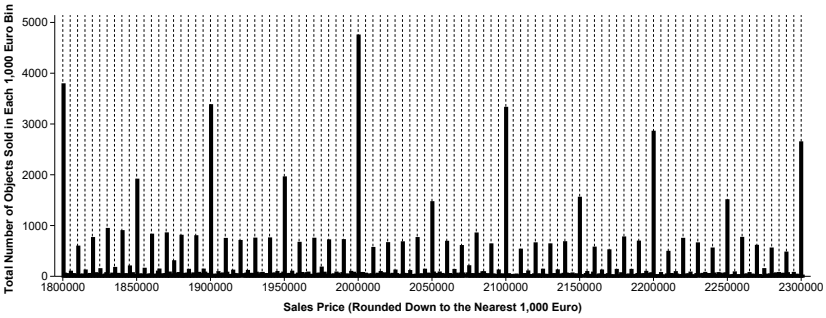
(a) Residential Real Estate (Price Range: 1,800,000 - 2,300,000 Euro)



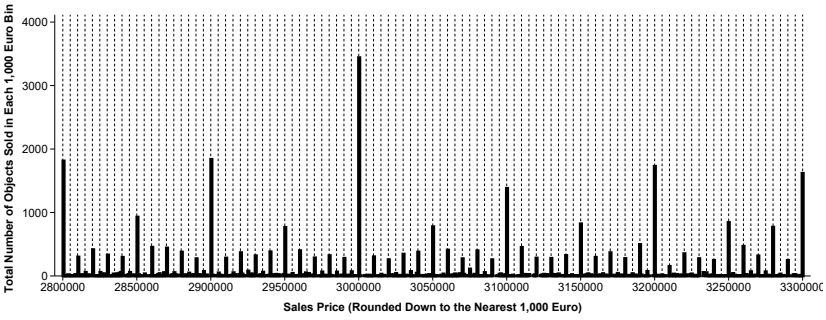
(b) Residential Real Estate (Price Range: 2,800,000 - 3,300,000 Euro)



(c) Commercial Real Estate (Price Range: 1,800,000 - 2,300,000 Euro)



(d) Commercial Real Estate (Price Range: 2,800,000 - 3,300,000 Euro)



Note: The note below Figure 1 applies, except that Panels (a) and (c) ((b) and (d)) consider objects with sales prices between 1,800,000 and 2,300,000 Euro (2,800,000 and 3,300,000 Euro).