

The German Open-End Fund Crisis – A Valuation Problem?

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Abstract Using a unique dataset of appraised values and transaction prices, this paper investigates whether systematic over-appraisals could have been at the heart of the 2005/2006 German open-end fund crisis. Because sold properties are valued more closely to market values than unsold properties, we develop a hedonic pricing model that controls for sample selectivity. The resulting estimates of prices achievable in the market are then compared to appraised values. Our results show that the properties held by open-end real estate funds were likely to have been overvalued prior to the crisis. This supports the view that a fundamentally justified run was at the heart of the 2005/2006 crisis, and it challenges the effectiveness of current valuation practices.

Keywords Appraisal-based valuation · Transaction-based valuation · Hedonic pricing · Commercial real estate · Open-end real estate funds

JEL Classification G11 · G14 · G24

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Introduction

This paper looks into the causes for the 2005/2006 German open-end funds crisis, which followed a prolonged period of high vacancy rates and falling rents in the German commercial real estate market. At the peak of the crisis, between December 2005 and March 2006, investors withdrew more than EUR 12 billion, which accounted for roughly 13 % of total assets under management at that time. In response to the unprecedented demand in liquidity, three funds temporarily suspended the redemption of their shares.¹ Already between November 2003 and November 2005 fund parent companies had provided generous liquidity support in an attempt to contain mounting liquidity problems of their funds. While large-scale outflows had been avoided for quite some time – mainly due to liquidity support by the funds' parent companies – by December 2005, the crisis quickly spread to the entire sector. It was not until the end of 2006 that funds started to attract fresh money again. Fueled by a rallying German commercial property market and a thriving market abroad, German open-end funds experienced a short but pronounced upswing until October 2008, when the sector once again experienced large outflows. At that time, it was primarily institutional investors redeeming their shares in order to rebalance portfolios and secure liquidity in light of the US credit crisis. A dampened economic outlook and an expected cooling in real estate markets due to the financial and economic crisis led funds to temporarily suspend share redemption for several months. By the end of 2008, 11 funds were closed due to liquidity shortages. One year later, six funds, representing EUR 9.5 billion of assets under management, still remain closed.

Two opposing views have been expressed as to what was at the root of the 2005/2006 crisis: On the one hand, the crisis is explained by speculative withdrawals and self-fulfilling predictions on the part of investors. On the other hand, it is claimed that the run on assets had been fundamentally justified, with actual net asset values falling short of the values actually reported by the funds.² Supporting the former, (Banner et al. 2008) argue that a downgrade by rating agencies triggered an investor panic. Investors rushed to the exit, as soon as they anticipated that others would do likewise. Comparatively low valuation adjustments after the reopening of Deutsche Bank Grundbesitz is viewed as an indication supporting the panic hypothesis. The notion that appraised values were actually close to what could be achieved in the market is further supported by a study conducted by RICS/IPD (2008), which compares actual sales prices to prior valuations and finds positive or negligible negative deviations of properties sold by OEREFs prior to or during the crisis. By contrast, Crosby (2007) argues that the smoothing and lagging of property valuations had created a situation where appraised values were no longer backed by the prices that could be achieved in the market. He devises an explicit critique of the German valuation system claiming that the failure of appraised values to adjust

¹German investment law explicitly provides for the possibility to close a fund due to liquidity problems. However, since the introduction of OEREFs in 1959, this rule had been not been tested prior to the 2005/2006 crisis.

²Of course, the two views presented here are not mutually exclusive. In fact, bad fundamentals and a speculative momentum may well have interacted during the crisis.

to the prolonged downswing in the property market can be seen as the primary cause for the subsequent crisis. According to this view, the run on open-end funds in 2005/2006 had been fundamentally justified, calling for a reform of current valuation practices.

Following the incidents of 2005/2006 a number of regulatory proposals were considered to prevent future crises. The regulatory changes that followed suit primarily targeted the valuation practice of open-end funds. However, the measures implemented had limited scope and were based merely on anecdotal evidence regarding potential insufficiencies of the valuation system. A rigorous empirical assessment aimed at determining whether appraised values reacted too late to changes in the market, i.e., whether the crisis was fundamentally justified, has been missing until now.

To revive the regulatory debate, and base it on a broader empirical footing, this paper explores whether appraisals systematically exceeded prices achievable in the market prior to the crisis. In so doing, we propose a novel analytical approach that fits squarely into recent work related to property valuation and hedonic pricing: We compare appraisal values of *non-transacted* properties to our own estimate of prices achievable in the market, which we derive from our hedonic pricing model. This is fundamentally different from earlier studies such as RICS/IPD (2008), who compare the prices of *transacted* properties to preceding appraisal values. Thus, apart from offering a direct response to the German open-end fund crisis of 2005/2006, this paper also makes a methodological contribution to the broader literature on valuation accuracy.

Our analysis proceeds in several steps. First, we apply simple hedonic pricing techniques based on OLS (ordinary least squares) to transaction prices, appraised values, and a sample combining the two. Second, we follow (Fisher et al. 2003) as well as (Fisher et al. 2007) in modeling the real estate market as a two-sided search-market with heterogeneous sellers and heterogeneous properties, where transactions are observed only if the buyer's reservation price exceeds that of the seller. Applying Heckman's two-step selection model we take into account the likelihood of a property being sold in the first place, thereby controlling for possible sample selection bias. The "valuation reserve", i.e., the difference between predicted values from a naive hedonic model and actual valuations, serves as an important input variable for the selection model. The choice of this variable follows from our finding that properties sold were valued closer to the market than properties held. Finally, we use mass appraisal based on our hedonic model in order to compare hedonic transaction prices to the actual appraised value. Throughout our analysis, we control for open-end real estate funds presumably being distinguished compared to other types of investors, for instance, in their propensity to sell during the crisis, or with regard to legal requirements affecting the valuation procedure.

We find that properties held by open-end funds were overvalued in comparison to the prices that could have been achieved on the market. Moreover, the properties sold tended to be valued more conservatively than the properties held. A property's valuation reserve (i.e., its degree of over- or undervaluation) seems to be a good predictor of its likelihood of being sold. Our results challenge the effectiveness of current valuation practices of German open-end funds, which could have been an important factor

in the crisis of 2005/2006. At the same time, our findings question the validity of previous studies, which do not take into account selection problems in transaction-based data. While our results support the view of a fundamentally justified run at the heart of the 2005/2006 open-end fund crisis, we cannot confirm that valuation problems were more pronounced for open-end funds than for other types of investors.

The main part of this paper is organized as follows. Section [Institutional Background](#) provides a brief introduction to the institutional background of German open-end funds, with a special emphasis on the valuation practice of these funds. Section [Hypotheses](#) develops our hypotheses, while section [The Data](#) introduces the data. Section [Hedonic Regression Analysis](#) applies simple hedonic pricing techniques to our data, and Section [Hedonic Pricing with Heterogeneous Agents](#) considers a selection model in the tradition of Heckman (1974, 1979) to avoid selection bias. Section [Mass Appraisal](#) uses mass appraisal-based methods on both simple as well as the Heckman hedonic model to compare predicted hedonic prices to actual appraised values. Section [Conclusions](#) concludes.

Institutional Background

Established in 1959, public open-end real estate funds (OEREFs) represent the predominant vehicle for channeling German private capital flows into domestic and international commercial real estate markets. German open-end funds are both an important funding source for the real estate industry in Germany as well as a popular asset class amongst retail investors. By mid 2008 total fund volume accounted for almost EUR 90 bn, equivalent to one quarter of the US real estate investment trust (REIT) market and one quarter of the total German mutual fund market. Although German REITs had been introduced by March 2007, open-end funds continue to be the predominant means of how retail clients participate in commercial real estate markets.³ Despite the well-known difficulties of the open-end fund structure, other countries have recently introduced public open-end funds shaped after the German model. Open-end real estate funds are now available in twelve European Union member states, although market capitalization in countries other than Germany is still small (see European Commission ed. (2008)).

To provide a brief introduction to the institutional background of the German open-end fund model, the following paragraphs provide a selective review of (i) the structure of German open-end real estate funds, (ii) the German valuation system, and (iii) the valuation practice of open-end real estate funds.

German Open-end Real Estate Funds

In essence, German open-end real estate funds resemble equity or bond mutual funds in that the funds do not have a fixed number of outstanding units. Instead, the number of shares changes, as such funds continually stand ready to both issue new shares

³By the end of 2009 only two German REITs were issuing shares, i.e., Alstria Office and Fair Value.

and redeem outstanding ones. However, German open-end funds have some distinctive features, which make for a rather exceptional investment vehicle. Most notably, their net asset value is determined by regular valuations of the underlying properties involved. Fluctuations in share price will result mainly from changes in the valuation of fund property holdings. Of course, price changes for other security holdings, rental and interest income, as well as construction and maintenance expenses will also affect a fund's net asset value.

Although fund shares are not traded on a secondary market (e.g., the stock exchange), they are highly liquid because investors can ask to redeem them on a daily basis. This stands in contrast to the real estate market, where asset liquidation usually takes a long time and involves high transaction costs. The open-end fund structure therefore allows for investing in property without bearing any of the disadvantages typically associated with holding an illiquid asset. In other words, OEREF investors may participate in the earnings of (illiquid) real estate, while being insured against unexpected liquidity needs. Such transformation of liquidation terms, however, comes at a price. Because OEREFs finance long-term assets by short-term claims, they can be subject to a “bank run”, with investors suddenly demanding redemption of their shares, and where a fund has difficulties to provide for sufficient liquidity. This is exactly what happened during the 2005/2006 open-end fund crisis – and again by October 2008 in the light of the worldwide financial crisis.

The German Valuation System

The German valuation system, including its legal foundations, bears a number of peculiarities which may have contributed to the 2005/2006 open-end fund crisis. German valuation practice – in particular the valuation practice of open-end funds – is frequently accused of being not only unique in its institutional setting but also concerning the degree of smoothness it achieves. Formally adhering to a market value concept, German valuers are perceived to merely deliver on the promises made by fund managers who advertise a “steady growth” and “low volatility” investment alternative. With respect to the German system, smoothing and lagging may be linked to valuers undertaking both financial statement and lending valuations (Crosby 2007). Although the formal basis of valuation in commercial real estate markets is not “sustainable value” as defined in mortgage lending, valuers may be influenced by sustainable value concepts when undertaking what are supposedly market valuations. Crosby (2007) argues that the German definition of market value may be more prone to such an erroneous alignment than definitions used in the UK. While definitions formerly used by TEGoVA (The European Group of Valuers Associations) and RICS (Royal Institution of Chartered Surveyors) are based on the concept of “best price, which could be reasonably obtained in the open market”, the German definition according to federal law (BauGB, §194) is conceptualized as an average price that would be “attainable in normal business dealings [...] without regard to unusual or personal circumstances” (Downie et al. 1996, p. 138). Thus, the law explicitly refers to an average rather than to a best price concept, which need not be a bad thing per se, as it prevents temporary market movements from finding their ways into valuations.

In addition to the principles stated in the BauGB, the widespread reference to codified valuation approaches has a large influence on German valuation practice. Codified approaches include the sales comparison approach (Vergleichswertverfahren), the German income approach (Ertragswertverfahren) and the German cost approach (Sachwertverfahren). Although these guidelines are not legally binding – at least not for nonofficial use – they are generally accepted by the industry as best practices and applied in standard valuation procedures. All three methods are conceptually consistent with methods used in the UK and internationally, but differ fundamentally in their application (Downie et al. 1996). A case in point is the separate consideration of the value of the land and the building: According to German valuation guidelines (WertV and WertR) the land can be used indefinitely, while the buildings are assumed to have a limited economic lifespan. Apart from the codified valuation approaches, the WertV and WertR leave open the possibility to use further methods, such as the discounted cash-flow (DCF) approach. However, many German valuers tend to dismiss the use of the DCF method as being more complicated compared to the German income approach and less transparent due to lacking or inadequate market information (McParland et al. 2002). Thus, traditionally the income approach has been the most widely used method for the valuation of commercial rental property. As mentioned above, separation of the value of the land and the premises is a distinct feature of the German income approach. Thereby, the value of the land is determined by the sales comparison approach using data provided by an official board of expert evaluators (Gutachterausschuss). A fictive annual return on the land value (opportunity cost of using the land) will be deducted from the yearly net income in order to derive the income attributable to the building and hence, its value. Finally, the property value is calculated as the sum of the land value and the value of the premises.

Valuation Practice of Open-end Funds

German investment law (InvG) does not oblige open-ended funds to use a particular valuation approach. In practice though, most funds rely on the codified German income approach as described above. Funds are prohibited from using their own (internal) valuations. Instead, they rely on externally and independently appraised values, which are legally binding for the investment company. German investment law requires funds to install a standing committee of at least three independent valuers. The committee meets regularly and checks each other's valuations whenever required. Fund managers are not admitted to the committee meetings. Since the latest amendment of the German investment law, which came into effect by the end of 2007, the valuer in charge is required to rotate every two years. Moreover, German investment law imposes restrictions on the share of income a valuer is allowed to receive from a single customer. The German supervisory authority (BaFin) monitors the valuers and ensures that legal requirements with regard to economic independence and professional expertise are fulfilled.

Adding to the system of checks and balances between investors and the investment company, fund managers can only dispose of the fund's assets in accordance with the depository bank. The depository bank, in turn, has to ensure that all disposals by the

fund management are legitimate. At the same time, the depository bank is responsible for the issuance and the remittance of fund shares and determines share offering and redemption prices. It does so by calculating the net asset value of the fund's portfolio on a daily basis. All properties are included at purchase price for the first year. Thereafter, German investment law requires each property to be re-valued at least once a year, although in special circumstances a more frequent revaluation may be required. Between the due dates, properties enter a fund's net asset value (NAV) with constant value. Basically, such valuation practice produces a yearly index with partial updating over the year, since only a twelfth of a fund's real estate portfolio is valued each month. Because funds want to avoid large price jumps, they tend to evenly spread the due dates for different properties throughout the year.

Finally, German open-ended funds are generally prohibited from selling property below their latest market value. Only if two or more properties are sold en bloc, transaction prices are allowed to fall short of valuations by as much as 5 % (InvG, §82).⁴ In rising markets such restriction are hardly binding as valuations regularly lag transaction prices. However, following a downward correction, properties may well be overvalued, thus effectively banning them from a sale.

Hypotheses

Incomplete processing of information by valuers – rationally or not – is well documented at an international level. Geltner (1989), Geltner et al. (2003), Diaz and Wolverton (1998), Brown and Matysiak (2000), Clayton et al. (2001), McAllister et al. (2004), and Edelstein and Quan (2006) all provide evidence for appraisal smoothing and lagging at the individual property level for either the UK or the US market. Although no comparable evidence exists yet for the German market, some observers note that German valuers tend *not* to adjust the value of properties during large market upswings, but rather to wait and see whether the movements are transitory or longer lasting (Kilbinger 2006). Maurer et al. (2004) show that OEREFs display exceptionally low return volatility and are highly serially correlated, which may be interpreted as funds trying to smooth capital gains.⁵

Presuming that valuers actually smooth the ups and the downs of the market, Crosby (2007) argues that during a prolonged period of high vacancy rates and falling rents, the gap between appraised values and transaction prices may have widened over time – eventually leading to a situation where portfolio values were no longer backed by the prices that could be achieved in the market. As soon as investors realized the valuation mismatch, they tried to redeem their shares, being granted an overly optimistic price. Ironically, when fund outflows peaked at the beginning of 2006, market information by Jones Lang LaSalle suggested that prices were already rising again, i.e., prime yields were falling. At the same time, the appraisal based index

⁴Until the end of 2007 sale prices were allowed to “marginally” fall short of valuations.

⁵Of course, one could follow (Shiller 1981) in arguing that the volatility of market prices may actually be too high relative to the volatility of the underlying income stream. Appraisals would then be merely trying to eliminate excess volatility.

DIX (German annual real estate index, provided by Investment Property Database IPD Germany) showed a further decline of capital values, lending further support to the notion that appraisal-based values in the meantime had become detached from the market. We formulate our first hypothesis accordingly:

Hypothesis 1: *The open-end fund crisis of 2005/2006 was preceded by a systematic divergence of prices observed in the market relative to appraised values.*⁶

If we hypothesize that an overly optimistic valuation had been at the heart of the crisis, how can we reconcile this with the evidence brought forward by RICS/IPD (2008) that prices observed did not deviate much from prior valuations? By logical reasoning it follows that properties sold must have been valued more closely to the expected sales price compared to the ones that were not sold. In other words, the inner reserves of properties sold were larger – or the hidden losses were smaller – compared to those of properties held. There are several explanations commensurate with this hypothesis. One possibility is that fund managers put up for sale only those properties that showed low deviation from the expected sales price in the first place, i.e., the “self-selection” hypothesis. A second possibility is that fund management exerted direct or indirect pressure on appraisers to devalue properties before they were sold, i.e., the “client influence” hypothesis (Baum et al. 2000; Deborah and Schuck 2005; Wolverton and Gallimore 1999). As a third alternative, appraisals close to transaction date already had incorporated information from negotiations or had influenced the negotiation process leading to an alignment of the appraised value with the actual sales price, i.e., the “information spill-over” hypothesis.⁷

Because selling a previously overvalued property will negatively affect book profits, we hypothesize that fund managers are less inclined to pick such a property for sale – even if a manager could rely on the valuer adjusting the valuation in order to bring the appraised value closer to the sales price. In the case of OEREFs, there is even stronger reason to believe that properties which are put up for sale display relatively high valuation accuracy, since open-end funds are legally prohibited from selling a property below its appraised value. This leads to our second hypothesis:

Hypothesis 2: *We observe transactions only for those properties that are not overvalued compared to the market.*

Analysis of sale transaction prices provided by RICS/IPD (2008) suggests that gaps between sales prices and prior valuations were less pronounced for open-end funds compared to other groups of investors over the period 1998–2007. This is exactly the kind of evidence one would expect if open-end funds were prohibited from selling below the appraised value (which they are). However, it does not say anything about valuation accuracy of the properties that were *held* by the funds – the ultimate issue this paper tries to address. If we want to assess valuation accuracy vis-à-vis the market, we need to account for the possibility that properties sold may not represent a random draw from the overall portfolio held by investors. We do this

⁶Note that there can be a valuation mismatch either with or without smoothing and lagging being present.

⁷By excluding observations of appraised values shortly before a transaction took place, we are able to rule out the “information spill-over” hypothesis. Excluding observations prior to sales furthermore reduces the likelihood of dealing with appraised values that are influenced by clients.

by means of mass appraisal of the properties held based on a selection model in the tradition of Heckman (1974, 1979).

Compared with closed-end investment vehicles, it has been argued that the open-end fund structure serves as a disciplining device vis-à-vis fund management, because investors may easily withdraw their funds if they deem the fund performs poorly (Bannier et al. 2008; Sebastian and Strohsal 2011). Thus, managers of OEREFs must be particularly concerned with fund performance. Against this backdrop, OEREFs have been frequently accused of directly or indirectly influencing valuers in order to reduce return variability (Glaesner 2009; Crosby 2007). However, to the extent that fund managers are able to affect the valuation process they face a dilemma. On the one hand, managers must be concerned with fund performance as noted above. On the other hand, they want to avoid a situation where appraised values are no longer backed by prices paid in the market, preferring a timely and accurate pricing of portfolio values. Eventually, investors will withdraw their funds, either because they deem the fund to be poorly performing, or because they are no longer convinced that redemption prices are backed by appraisal-based values. As a third possibility, there may be no client influence in the first place. Whether OEREFs display higher or lower valuation accuracy relative to pension funds, insurance companies, or asset managers becomes an empirical issue. We postulate our third hypothesis as follows:

Hypothesis 3: *Valuation problems were more pronounced for OEREFs compared to those faced by other types of investors.*

The Data

We explore a unique dataset provided by the German branch of IPD Investment Property Database, a private service provider that offers portfolio analysis to institutional real estate clients. As part of its service agreement, the IPD collects, stores, and analyzes data from client portfolios, including information on characteristics at an individual property level, such as size, age, location, rent, vacancy rates, and capital expenditures, which feed into expert appraisals. Overall, the IPD dataset consists of annual information on 7,596 individual properties. The panel contains information on purchase prices, as well as repeated annual appraisals. In the year in which a property is sold, it exits the panel with its transaction price.⁸

We restrict our sample to include office properties between 1999 and 2007 – including office properties with mixed commercial use. Although some data exists for the year 1998, there are not sufficient observations to estimate any meaningful coefficient on the time dummy. The layout of our sample follows the standard classification used for calculating property price indices, such as those used by the IPD and

⁸By the end of 2007, the IPD database contained about 3,800 properties, with a total market value of EUR 44.5bn. Thereof, office properties (47 %) accounted for the largest fraction in volume terms, followed by other properties (22 %), retail (19 %) and residential properties (11 %). In terms of investor coverage, properties of the IPD database were held by open-end funds (42 %), insurance and pension funds (39 %), asset managers (13 %), and special real estate funds (6 %).

Table 1 Number of property-year observations

	All yrs.	1999	2000	2001	2002	2003	2004	2005	2006	2007
All property types										
Overall sample	36,441	2945	3606	4122	3903	3996	4019	4115	5327	4408
Appraised values	32,715	2,864	3,498	3,591	3,406	3,710	3,682	3,663	4,499	3,802
Transactions	3,726	81	108	531	497	286	337	452	828	606
Offices and mixed use										
Overall sample	15,793	1,397	1,650	1,750	1,723	1,884	1,948	1,973	1,953	1,515
Cleaned sample*	15,587	1,382	1,636	1,737	1,701	1,860	1,919	1,951	1,919	1,485
Appraised values	14,601	1,344	1,616	1,689	1,614	1,810	1,855	1,895	1,602	1,176
Transactions	986	38	20	48	87	50	64	56	314	309

*Excluding appraisals during the year of a sale, properties in redevelopment, and observations where data on lettable space or net income is missing.

other data providers. Generally, such indices distinguish among residential, retail, and office use. In our case, we believe it makes sense to focus on office properties, because open-end funds are primarily invested in those markets. Of course, it would also be possible to look at other markets using a similar methodology.

Note that we exclude observations of the year prior to a sale, during the year of a sale, and one year after a sale. The exclusion of observations around sale dates is intended to enhance the separation effect between transaction prices and appraisal-based values. It follows from the design of our analysis, which focuses on the ability to effectively price properties in line with the market – precisely when there is no timely anchor in the form of a recent or projected sales price. Excluding observations prior to sale dates eliminates information spill-over effects, i.e., the influence of the negotiation process onto the appraised value and vice versa.⁹ It furthermore reduces the likelihood of dealing with appraisal-based data that is subject to client influence, i.e., implicit or explicit pressure exerted by fund management on valuers to devalue a previously overvalued property, in order to make it more marketable. We further reduced our sample by excluding observations of properties in redevelopment, and when observations on space or net income are missing. Our resulting sample consists of information on 2,646 individual properties. The first column of Table 1 provides an overview of the overall number of cumulative observations for the entire dataset, the chosen sample, and the resulting sample to be used for our analysis, respectively. Subsequent columns show the number of individual property observations over the years, and how they are divided into appraisals and transactions.

Ultimately, we are left with 14,601 property-year observations of appraised values, and 986 observations of transaction prices. While the number of appraised values remains relatively constant over time, the number of property sales varies substantially. During 2006 and 2007, the annual number of properties sold was more than

⁹RICS/IPD (2008) exclude appraisal based values three months prior to a sale.

five times higher than in previous years. The relatively high number of sales may reflect rising liquidity needs on the part of the funds during these years. It may also be an indicator of rising prices, as the volume of trades generally increases during a market upswing (Fisher et al. 2003, 2007).

So far we have described the composition of our sample in terms of property-year observations. We will now turn to the description of the dependent variables as well as the hedonic factors used for the regression analysis. In line with the literature on hedonic pricing, we define the dependent variable as the property value or transaction price over lettable space.¹⁰ The selection of our regressors likewise is based on the literature subject to availability of the data. To capture regionally differing price levels, we introduce dummy variables for the 22 distinct local markets covered by our sample. Quality of the property is measured as the average sustainable net income divided by average area to let, where averages are taken over the sample-periods. Further hedonic regressors include the average rent normalized by the average area to rent, the economic age of a property, the vacancy rate, as well as the value of the land, all taken from the valuation reports. We also include a dummy indicating whether a property was combining retail and office use or rented out for office use only. Finally, we include the average area-to-let in order to capture the size of a property. Except for the dummy variables, all regressors enter the regression equations in log terms. Table 2 displays summary statistics of the key variables, for each of the subsamples as well as the combined sample.

Hedonic Regression Analysis

Our hedonic regression analysis follows a twofold approach. We estimate a naive hedonic price index for the two sub-samples: the first, including the appraised values and the second, restricted to transaction prices. We compare the two indices with each other in order to assess whether prices of transacted properties evolved differently over time relative to properties that were held by the investors. Second, we look at the combined sample including both, transaction prices as well as appraised values. Controlling for the hedonic factors, we try to find out in general whether properties sold were over- or undervalued compared to properties held by the investor. In particular, we test Hypothesis 1 by exploring how over- or undervaluation of properties belonging to an open-end fund evolved over time.

Transaction- Versus Appraisal-based Naive Index

We start by estimating a naive hedonic model for the two sub-samples, i.e., the appraised values and the transaction prices, respectively. While we look at transaction prices and appraised values alternatively on the left-hand side of the regression equation, we ensure that the regressors (i.e., the hedonic factors) are comparable

¹⁰For a review of the literature on hedonic pricing models see Malpezzi (2002)

across both sub-samples. This allows us to later compare the two sub-indices with each other. We estimate the following specification:

$$P_{it}^{tp} = \sum \alpha_j^{tp} X_{ijt} + \sum \beta_t^{tp} Z_t + \varepsilon_{it}^{tp}, i \in \text{transaction prices} \quad (1)$$

$$P_{it}^{av} = \sum \alpha_j^{av} X_{ijt} + \sum \beta_t^{av} Z_t + \varepsilon_{it}^{av}, i \in \text{appraised values} \quad (2)$$

where P_{it}^{tp} and P_{it}^{av} are the natural logs of the transaction price or the appraised value of property i at time t respectively; X_{ijt} are the hedonic factors, such as location, age, income from the property etc.; Z_t are the time dummies and ε_{it}^{tp} and ε_{it}^{av} are the residual terms, which we assume to be independent and identically distributed with $\varepsilon_{it}^{tp} \sim iid(0, \sigma_{\varepsilon^{tp}}^2)$ and $\varepsilon_{it}^{av} \sim iid(0, \sigma_{\varepsilon^{av}}^2)$. Estimates for both sub-samples are obtained by OLS with heteroscedasticity robust standard errors.

Table 3 displays the regression results revealing a number of insights. First, the hedonic factors have the expected signs and are significant at the 5 % level, except for the variables capturing property size and the property's use (i.e. mixed office and commercial use). Furthermore, there seems to be a premium for both properties held and sold by OEREFs, which is not captured by the hedonic factors. At first glance, this premium appears to be more pronounced for properties sold than for properties held. Interpretation of this result is not straightforward though, since we do not know

Table 2 Descriptive statistics of selected variables

Variable	Mean	StDev	Min	Max	Obs
Combined sample					
Price or value/sqm (EUR)	2,336.8	1,455.9	31.4	16,542.0	15,587
Quality (EUR)	153.6	66.5	23.2	661.5	15,378
Rent (EUR)	143.0	69.3	20.5	635.3	15,408
Age (years)	19.0	13.8	0.0	57.0	15,157
Vacancy (%)	10.2	19.6	0.0	100.0	15,109
Sqm (m2)	8,210.8	9,729.8	104.0	104,679.3	15,587
Land (EUR)	834.4	836.3	33.8	9,098.4	13,794
LARGE	10.0 %	0.3	0.0	1.0	15,587
SMALL	10.0 %	0.3	0.0	1.0	15,587
MIXED	19.7 %	0.4	0.0	1.0	15,587
OEREF	37.0 %	0.5	0.0	1.0	15,587
Appraised values					
Value/sqm (EUR)	2,364	1,459.8	31.4	16,542	14,601
Quality (EUR)	154.5	66.6	23.2	661.5	14,438
Rent (EUR)	143.7	69.5	20.5	635.3	14,434
Age (years)	18.6	13.7	0.0	57.0	14,200
Vacancy (%)	10.5	19.9	0.0	100.0	14,224
Sqm (m2)	8,255	9,701.1	104.0	104,679.3	14,601
Land (EUR)	833.5	838.3	33.8	9,098.4	13,000
LARGE	10.1 %	0.3	0.0	1.0	14,601
SMALL	9.8 %	0.3	0.0	1.0	14,601
MIXED	19.5 %	0.4	0.0	1.0	14,601
OEREF	37.2 %	0.5	0.0	1.0	14,601

Table 2 (continued)

Variable	Mean	StDev	Min	Max	Obs
Transactions					
Price/sqm (EUR)	1,934.8	1,334.3	124.2	11,644.5	986
Quality (EUR)	140.5	62.9	23.2	661.5	940
Rent (EUR)	131.9	65.3	20.5	530.4	974
Age (years)	24.7	14.1	0.0	57.0	957
Vacancy (%)	4.9	12.9	0.0	74.3	885
Sqm (m ²)	7,555.6	10,128.5	104.0	87,719	986
Land (EUR)	848.4	804.1	37.0	4,751.9	794
LARGE	9.6 %	0.3	0.0	1.0	986
SMALL	13.2 %	0.3	0.0	1.0	986
MIXED	22.7 %	0.4	0.0	1.0	986
OEREF	33.8 %	0.5	0.0	1.0	986

Price/sqm Transaction price per square meter adjusted by capital expenditures

Value/sqm Appraised value per square meter

Quality Average sustainable net income divided by average area to let

Rent Average rent divided by average area to let

Age Economic age

Vacancy Vacancy rate

Sqm Average area to let, averaged over all periods observed

Land Value of the build land

LARGE Dummy, 1 if a property belongs to the 10 % largest properties, 0 else

SMALL Dummy, 1 if a property belongs to the 10 % smallest properties, 0 else

MIXED Dummy, 1 if a property is combining retail and office use, 0 else

OEREF Dummy, 1 if a property belongs to an open-end fund, 0 else

whether a hedonic factor is missing (for instance the potential to further develop the property) or whether the results reflect the fact that appraised values of OEREFs are overly optimistic, and that OEREFs are able to sell at higher prices.

Using linear predictions based on Eqs. 1 and 2 we construct two distinct indices, one based on transaction prices only and the other restricted to appraised values. Both indices are evaluated for the same representative property held or sold by an open-end fund. For size, age, quality, rent and land we use mean values of the entire sample, respectively. Furthermore, we assume that the property is located in Frankfurt.¹¹ Figure 1 displays the hedonic indices, for both transaction prices as well as appraised values derived from Eqs. 1 and 2.

Looking at variation over time, one can see that appraised values were constantly falling from 2002 onwards until the end of the sample period. While this picture broadly fits with the DIX, the annual capital return index based on appraised values calculated by the IPD, it is at odds with anecdotal evidence claiming that prices

¹¹ Frankfurt hosts the largest fraction of properties in our sample. The dummy variable is omitted from our regression equation.

Table 3 Naive hedonic model – distinct samples, OLS

	(1) ln(Price/sqm)		(2) ln(Value/sqm)	
y99	0.502***	(5.76)	0.0700***	(6.64)
y00	0.173***	(3.50)	0.0913***	(9.13)
y01	0.146**	(2.72)	0.0928***	(9.32)
y02	0.191***	(5.57)	0.1000***	(10.22)
y03	0.112**	(3.02)	0.0798***	(8.18)
y04	0.119***	(3.45)	0.0503***	(5.19)
y05	0.0931*	(2.03)	-0.0113	(-1.12)
y07	0.134***	(5.10)	0.0113	(1.07)
ln(quality)	0.735***	(9.68)	0.898***	(29.95)
ln(rent)	0.326***	(5.40)	0.130***	(6.62)
ln(age)	-0.0821***	(-4.89)	-0.0549***	(-10.76)
ln(vacancy)	-0.00902	(-1.04)	-0.0212***	(-9.38)
ln(land)	0.121***	(7.04)	0.119***	(15.45)
ln(sqm)	0.291***	(4.53)	0.141***	(7.06)
LARGE	0.156***	(4.33)	-0.0182	(-1.91)
SMALL	-0.0644	(-1.66)	-0.00710	(-0.69)
MIXED	0.0199	(0.78)	0.00821	(1.54)
ST	0.139	(1.50)	0.00943	(0.47)
BW	0.0340	(0.45)	0.0397*	(2.38)
MU	0.0225	(0.42)	0.0102	(0.90)
BA	0.00637	(0.10)	-0.0278	(-1.73)
BL	-0.0199	(-0.36)	0.0569***	(3.85)
BB	0.247*	(2.17)	0.0935*	(2.44)
BR	-0.0508	(-0.60)	-0.0292	(-1.16)
HH	0.0464	(0.86)	0.0595***	(4.91)
HE	-0.0293	(-0.46)	-0.0123	(-0.89)
MV	-0.241	(-1.58)	0.109**	(3.06)
NS	0.0127	(0.19)	0.00511	(0.32)
DU	0.0203	(0.38)	0.0507***	(4.26)
NW	-0.000450	(-0.01)	0.00639	(0.44)
KO	0.0833	(1.26)	0.0130	(0.91)
RP	-0.0780	(-0.75)	0.0132	(0.63)
SL	-0.0172	(-0.15)	-0.0723*	(-2.25)
LP	-0.0691	(-0.86)	0.0807**	(3.19)
SS	0.132	(1.39)	0.0843***	(3.36)
SA	0.0557	(0.72)	0.135***	(4.35)
SH	-0.0435	(-0.44)	-0.0363	(-1.77)
TH	0.0349	(0.39)	0.0520*	(2.45)

Table 3 (continued)

	(1)		(2)	
	ln(Price/sqm)		ln(Value/sqm)	
OEREF	0.130***	(5.54)	0.0854***	(15.95)
Constant	1.846***	(5.88)	1.746***	(19.15)
Observations	986		14601	
Adjusted R^2	0.785		0.790	
AIC	444.5		2530.8	
BIC	640.2		2834.4	

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$ Table 3 displays the regression results for a naive hedonic model. Specification 1 shows the results for a sub-sample of transaction prices, where the dependent variable is the natural log of the transaction price per square meter. Specification 2 shows the results for a sub-sample of appraised value, where the dependent variable is the natural log of the appraised value per square meter. The regressors are ln(Price/sqm): natural log of the transaction price per square meter; Y99-Y07: yearly dummies from 1999 to 2007; ln(Quality): ln of sustainable net income divided by area to let; ln(Rent) ln of rent divided by area to let; ln(Age): ln of economic age; ln(Vacancy): ln of vacancy rate; ln(Sqm): ln of area to let; ln(Land): ln of value of the build land; LARGE: 1 if a property belongs to the 10 % largest properties, 0 else; SMALL: 1 if a property belongs to the 10 % smallest properties, 0 else; MIXED: 1 if a property is combining retail and office use, 0 else; ST-TH: regional dummies; OEREF: 1 if a property belongs to an open-end fund, 0 else.

achieved in the market were rising again between 2006 and 2007. Also, it contrasts with the transaction-based index from our calculations. Here, the index declined from 2001 until 2006 but rose again in 2007. Also, the appraisals-based index looks much smoother compared to the transaction-based index, which is in line with international evidence showing that transaction-based indices tend to display greater volatility than appraisal-based indices. In our case, additional volatility may also be the result of a much smaller sample of transaction prices compared to the appraised values.

Hedonic Analysis of the Combined Sample

In a next step, we try to look further into possible valuation differences between properties held and sold. To this end, we explore the combined sample including observations of properties sold (transaction prices) as well as observations of properties held (appraised values). Based on the combined sample we try to assess whether properties sold were over- or undervalued compared to properties held, and how valuation differences for properties sold by open-end funds evolved over time (Hypothesis 1). Again, we start by estimating a simple hedonic model according to the following specification:

$$P_{it} = \sum \alpha_j X_{ijt} + \sum \beta_t Z_t + \varepsilon_{it} \tag{3}$$

where P_{it} is the appraised value or alternatively the transaction price of property i at time t depending on whether a property was held or sold; $\alpha_j X_{ijt}$ are the hedonic factors including a dummy that captures whether a property is held or sold

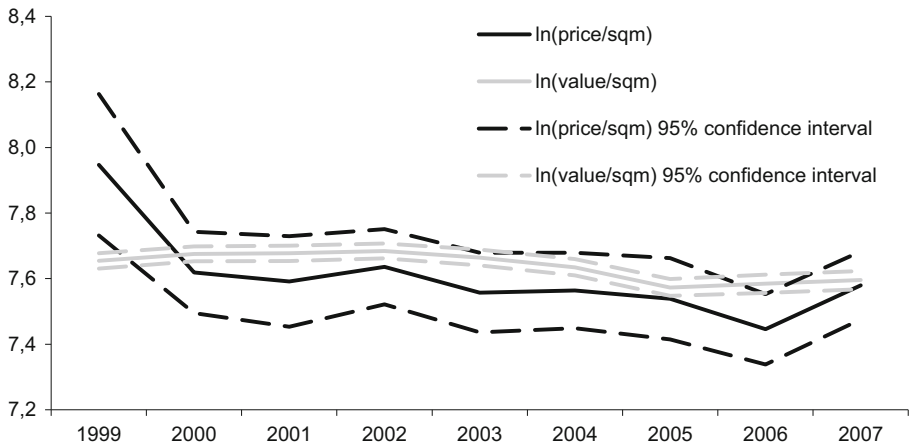


Fig. 1 Hedonic price indices – transaction prices vs. appraised values. Figure 1 displays the hedonic price indices for both transaction prices as well as appraised values, i.e. linear predictions from the hedonic regressions holding the hedonic factors constant. The dotted lines represent the 95% upper and lower bound confidence interval around the point estimates

by an open-end fund; $\beta_t Z_t$ are the time dummies and ε_{it} is the residual term, which we assume to be independent and identically distributed with $\varepsilon_{it} \sim iid(0, \sigma_\varepsilon^2)$.

Within a further specification, we add an additional dummy variable “Sale”, which takes the value of one if the property value observed is a transaction price and zero if it is an appraised value. This dummy captures systematic differences in transaction prices relative to appraised values. Similarly, “OEREF” takes the value 1 if the property is held or sold by an open-end fund and 0 otherwise. Finally, we interact the OEREF dummy with the “Sale” dummy for each period respectively. This allows us to extract information regarding the under- or overvaluation of properties sold by open-end funds compared to the overall hedonic model. Estimates for all specification are obtained by OLS with heteroscedasticity robust standard errors. Table 4 displays the regression results.

The results from specification 1 (see Table 4) confirm our conclusion for the distinct samples. There seems to be a premium for properties held or sold by OEREFs. Moreover, holding the hedonic factors constant, Specification 2 rejects the hypothesis that properties held are valued equal to properties sold. Conversely, sales prices seem to be too low or appraised values too high relative to each other. This result is consistent with the notion that properties hold are overvalued compared to what could have been reasonably achieved in the market. Finally, we find that over- or undervaluation of properties sold by OEREFs varies over time. According to the coefficient estimates of the interacted terms within Specification 3, prices achieved in the market appear to have been in line with the overall hedonic model for the years 1999–2001 and 2005, while prior to the crisis, during the period from 2002 until 2004, properties sold were sold below what could have been justified by the hedonic model. We find the greatest deviation in 2003, but also in 2006 prices achieved in the market seem to have fallen short of the value justified by our hedonic model.

Table 4 Naive hedonic model – combined sample, OLS

	(1)		(2)		(3)	
	ln(Value or price/sqm)		ln(Value or price/sqm)		ln(Value or price/sqm)	
y99	0.107***	(10.32)	0.0940***	(8.90)	0.102***	(9.74)
y00	0.121***	(12.63)	0.107***	(11.06)	0.117***	(11.99)
y01	0.121***	(12.63)	0.108***	(11.20)	0.117***	(12.03)
y02	0.126***	(13.47)	0.115***	(12.37)	0.122***	(12.88)
y03	0.106***	(11.34)	0.0940***	(10.07)	0.102***	(10.74)
y04	0.0757***	(8.19)	0.0646***	(7.02)	0.0737***	(7.78)
y05	0.0166	(1.71)	0.00466	(0.48)	0.0124	(1.25)
y07	0.0310**	(3.16)	0.0350***	(3.60)	0.0257*	(2.50)
ln(quality)	0.885***	(31.06)	0.885***	(31.22)	0.885***	(31.01)
ln(rent)	0.153***	(8.14)	0.147***	(7.89)	0.153***	(8.13)
ln(age)	-0.0568***	(-11.39)	-0.0554***	(-11.19)	-0.0565***	(-11.31)
ln(vacancy)	-0.0172***	(-7.87)	-0.0198***	(-9.10)	-0.0174***	(-7.89)
ln(land)	0.117***	(15.96)	0.118***	(16.13)	0.117***	(15.94)
ln(sqm)	0.163***	(8.52)	0.156***	(8.23)	0.163***	(8.49)
LARGE	-0.0103	(-1.12)	-0.00889	(-0.96)	-0.00988	(-1.07)
SMALL	-0.00991	(-0.99)	-0.00993	(-1.00)	-0.0102	(-1.02)
MIXED	0.00776	(1.47)	0.00842	(1.61)	0.00801	(1.52)
ST	0.0200	(1.02)	0.0170	(0.86)	0.0201	(1.02)
BW	0.0401*	(2.44)	0.0392*	(2.39)	0.0401*	(2.44)
MU	0.0142	(1.27)	0.0128	(1.14)	0.0148	(1.32)
BA	-0.0256	(-1.63)	-0.0256	(-1.64)	-0.0254	(-1.62)
BL	0.0553***	(3.83)	0.0553***	(3.84)	0.0552***	(3.83)
BB	0.101**	(2.87)	0.104**	(2.90)	0.0999**	(2.83)
BR	-0.0343	(-1.42)	-0.0334	(-1.39)	-0.0339	(-1.40)
HH	0.0610***	(5.12)	0.0591***	(4.97)	0.0609***	(5.10)
HE	-0.0133	(-0.97)	-0.0138	(-1.00)	-0.0123	(-0.89)
MV	0.0928**	(2.60)	0.0920**	(2.60)	0.0924**	(2.58)
NS	0.00699	(0.44)	0.00512	(0.32)	0.00660	(0.42)
DU	0.0490***	(4.17)	0.0489***	(4.18)	0.0493***	(4.20)
NW	0.00635	(0.45)	0.00475	(0.33)	0.00597	(0.42)
KO	0.0180	(1.28)	0.0174	(1.24)	0.0179	(1.28)
RP	0.0111	(0.53)	0.00797	(0.38)	0.0109	(0.52)
SL	-0.0701*	(-2.24)	-0.0723*	(-2.32)	-0.0706*	(-2.25)
LP	0.0636*	(2.58)	0.0669**	(2.74)	0.0679**	(2.75)
SS	0.0867***	(3.54)	0.0869***	(3.53)	0.0881***	(3.60)
SA	0.130***	(4.46)	0.133***	(4.57)	0.129***	(4.43)
SH	-0.0412*	(-1.99)	-0.0392	(-1.90)	-0.0411*	(-1.98)
TH	0.0513*	(2.45)	0.0519*	(2.47)	0.0525*	(2.50)
OEREF	0.0854***	(16.38)	0.0876***	(16.76)	0.0882***	(16.77)

Table 4 (continued)

	(1)	(2)	(3)
	ln(Value or price/sqm)	ln(Value or price/sqm)	ln(Value or price/sqm)
sale_dummy		-0.0882*** (-8.28)	
OEREF*SALE*Y99			-0.0262 (-0.32)
OEREF*SALE*Y00			-0.0117 (-0.13)
OEREF*SALE*Y01			-0.0392 (-0.44)
OEREF*SALE*Y02			-0.124*** (-4.38)
OEREF*SALE*Y03			-0.402*** (-8.04)
OEREF*SALE*Y04			-0.122*** (-4.05)
OEREF*SALE*Y05			-0.0105 (-0.27)
OEREF*SALE*Y06			-0.0918** (-3.08)
OEREF*SALE*Y07			0.0112 (0.58)
Constant	1.690*** (19.19)	1.732*** (19.62)	1.695*** (19.24)
Observations	15587	15587	15587
Adjusted R ²	0.788	0.790	0.789
AIC	3190.8	3102.7	3183.4
BIC	3496.9	3416.5	3558.5

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$ Table 4 displays the regression results for a naive hedonic model, where the dependent variable combines both observations of transaction prices as well as appraised values. The regressors are ln(Price/sqm): natural log of the transaction price per square meter; Y99-Y07: yearly dummies from 1999 to 2007; ln(Quality): ln of sustainable net income divided by area to let; ln(Rent) ln of rent divided by area to let; ln(Age): ln of economic age; ln(Vacancy): ln of vacancy rate; ln(Sqm) ln of area to let; ln(Land): ln of value of the build land; LARGE: 1 if a property belongs to the 10 % largest properties, 0 else; SMALL: 1 if a property belongs to the 10 % smallest properties, 0 else; MIXED: 1 if a property is combining retail and office use, 0 else; ST-TH: regional dummies; OEREF: 1 if a property belongs to an open-end fund, 0 else; SALE: 1 if the dependent variable is a transaction price, 0 if it is an appraised value. The interaction terms in Specification 3 are included to assess how the differences between sale prices and appraised values of OEREFs change over time.

Hedonic Pricing with Heterogeneous Agents

In the previous section, we analyzed our data in the absence of an explicitly formulated theoretical foundation. In this section, we follow (Fisher et al. 2003, 2007) in modeling the real estate market as a two-sided search market, with heterogeneous agents and heterogeneous properties, where transactions are observed only if the buyer's reservation price exceeds that of the seller. Transactions, however, are a non-random sample of prices achievable in the market. This is because the reservation price of the seller can be affected by the preceding appraisal values. Selling below appraisal value may result in book losses, or may even be forbidden, as in the case of German open-end funds. Consequently, fund managers will be more inclined to sell properties that are valued in line with the market.

We address this empirically by calculating the “valuation reserve” for each property, the difference between the predicted value from our hedonic model and the actual appraised value or transaction price. On average, overvalued properties will have smaller valuation reserves. We show that this variable helps explain whether a property is sold, lending support to Hypothesis 2. Using Heckman procedures, we are able to account for sample selectivity and revisit Hypothesis 1. This time, we correct for a possible sample selection bias by analyzing whether appraisals were in line with prices achievable in the market.

Supply and Demand Side Reservation Prices

Equation 4 gives the reservation price on the demand side of the market, i.e., the maximum price the buyer is willing to pay:

$$RP_{it}^b = \sum \alpha_j^b X_{ijt} + \sum \beta_t^b Z_t + \varepsilon_{it}^b \tag{4}$$

where X_{ijt} are the hedonic characteristics of property i at time t ; α_j^b represent the coefficients of the hedonic factors X_{ijt} on the buyer’s reservation price; $\beta_t^b Z_t$ captures the change in reservation prices over time, when all other factors are kept constant; and ε_{it}^b represents the idiosyncratic error terms with mean zero. Analogous, on the supply side of the market, the minimum price the seller is willing to accept is given by the following equation:

$$RP_{it}^s = \sum \alpha_j^s X_{ijt} + \sum \beta_t^s Z_t + \sum \delta_j H_{ijt} + \varepsilon_{it}^s \tag{5}$$

In addition to the hedonic characteristics of a property and the point in time considered, the seller may take further factors into account when setting his or her reservation price. For instance, these factors include the propensity to sell given acute liquidity needs, the ease by which a property can be liquidated in a certain market or the difference between the expected sales price and the current book value.¹² Note that $\delta_j H_{ijt}$ influences the reservation price of the seller, and thus the sales probability, but does not affect the price that can be realized in the market.

Now, we would like to estimate the seller’s and buyer’s reservation price equation, respectively. However, we cannot observe reservation prices directly. Instead, we observe transaction prices only if the buyer’s reservation price exceeds that of the seller:

$$P_{it} = \begin{cases} \text{observed, if } RP_{it}^b \geq RP_{it}^s \\ \text{unobserved, if } RP_{it}^b < RP_{it}^s \end{cases} \tag{6}$$

The actual transaction price P_{it} is the outcome of a negotiation process between the seller and the buyer. Following Fisher et al. (2003, 2007) we assume that both sides have equal bargaining power and that the two parties settle the transaction at the midpoint between the seller’s and the buyer’s reservation price.¹³ Using the midpoint

¹²Here we depart from Fisher et al. (2003, 2007), who do not explicitly model the factors that determine the probability of a sale other than the hedonic factors.

¹³Fisher et al. (2003, 2007) use the midpoint assumption to identify the seller’s and buyer’s reservation price equation, respectively. Since our primary goal is to compensate for sample selection bias, rather than to identify the reservation price equation on either side of the market, any alternative assumption about bargaining power would be suitable.

assumption and Eq. 4 through Eq. 6 we see that the expected transaction price is given by:

$$E[P_{it}] = \sum \alpha_j X_{ijt} + \sum \beta_t Z_t + \frac{1}{2} \sum E[\delta_j H_{ijt} | P_{it}] + E[\varepsilon_{it} | P_{it}] \quad (7)$$

where P_{it} is the observed transaction price; $\alpha_j = \frac{1}{2}(\alpha_j^b + \alpha_j^s)$; $\beta_t = \frac{1}{2}(\beta_t^b + \beta_t^s)$; and $\varepsilon_{it} = \frac{1}{2}(\varepsilon_{it}^b + \varepsilon_{it}^s)$. Because $\sum \delta_j H_{ijt}$ are chosen to be independent of P_{it} , we can transform the relationship described above into the following regression equation, which yields our transaction-based hedonic pricing model:

$$P_{it} = \sum \alpha_j X_{ijt} + \sum \beta_t Z_t + (\varepsilon_{it} | P_{it}) \quad (8)$$

If $E[\varepsilon_{it} | P_{it}]$ is non-zero, i.e. if the error term is correlated with the decision to sell a property, OLS yields biased parameter estimates (Tobin 1958). For instance, if potential sellers were prohibited from selling below the appraised values, we would observe fewer transactions but relatively high transaction prices at times when this restriction was binding. In this case, estimated coefficients of the hedonic regression would overstate the influence on prices and the inferences based on actual transaction prices would not extend to the properties that were not sold.

A Hedonic Pricing Model with Selection

To answer our hypotheses, we need to confirm whether appraisals are in line with prices achievable in the market. However, market prices are only revealed if a property transacts. In all other cases, they remain limited by the reservation price of the seller, because it was not exceeded by the reservation price of the buyer. We can address this type of censoring by using the well-documented Heckman procedure (Heckman 1974, 1979). In the first step, we estimate the probability that a property is sold using a probit model. In the second step, information on the sales probability (the non-selection hazard) is included in the hedonic price model to control for the fact that a property had been sold in the first place. The use of Heckman's procedure is warranted if 1) selection into the sample is non-random, and 2) sample selection is non-deterministic, i.e., there are unmeasured variables that predict selection into the sample. In our case, whether a property is sold depends on a latent variable, notably the difference between the reservation price of the seller and that of the buyer. The following equation expresses this latent variable (Fisher et al. 2003, 2007):

$$S_{it}^* = RP_{it}^b - RP_{it}^s \quad (9)$$

A sale occurs if the latent variable S_{it}^* is larger than or equal to zero. Although we cannot observe the latent variable, we do know whether a sale was transacted or not:

$$S_{it} = \begin{cases} 1 & \text{if } S_{it}^* \geq 0 \\ 0 & \text{otherwise} \end{cases} \quad (10)$$

In order to derive the latent variable as in Eq. 9, we subtract the reservation price of the seller (5) from that of the buyer (1):

$$S_{it}^* = \sum \omega_j X_{ijt} + \sum \gamma_t Z_t - \sum \delta_j H_{ijt} + \eta_{it} \quad (11)$$

where $\omega_j = \alpha_j^b - \alpha_j^s$; $\gamma_t = \beta_t^b - \beta_t^s$; and $\eta_{it} = \varepsilon_{it}^b - \varepsilon_{it}^s$. As in Eqs. 4 and 5, X_{ijt} are the hedonic characteristics of property i at time t ; Z_t are the time dummies; and H_{ijt} are further factors on the supply-side of the market, which affect sales probability but have no influence on transaction prices as described above. Since there are further unmeasured variables that predict selection into the sample, $E[\eta_{it} | S_{it}^*]$ is non-zero. Based on the relationships in Eqs. 10 and 11, we can now formulate the probit model, which yields the probability of a sale given X_{ijt} , Z_t and H_{ijt} :

$$Pr[S_{it} = 1 | X_{ijt}, Z_t, H_{ijt}] = \Phi[\sum \omega_j X_{ijt} + \sum \gamma_t Z_t - \sum \delta_j H_{ijt}] \tag{12}$$

where $\Phi[]$ is the cumulative distribution function of the standard normal distribution. We can now calculate the non-selection hazard, or inverse Mills ratio, which is the probability density function of predicted values from Eq. 12 over the cumulative distribution function.¹⁴ Using the selection hazard as an additional regressor in our hedonic pricing model (13) removes the part of the error term correlated with the explanatory variables. At the same time it corrects for the fact that unobservable characteristics, which result in a higher transaction price, will also result in a higher probability of a sale. We obtain unbiased and consistent estimates for the transaction-based hedonic model by estimating the following regression:

$$P_{it}^{tp} = \sum \alpha_j X_{ijt} + \sum \beta_t Z_t + \sigma_{\varepsilon\eta} \lambda_{it} + v_{it} \tag{13}$$

where X_{ijt} are the hedonic factors; Z_t are the time dummies; λ_{it} is the inverse Mills ratio calculated for each property i at time t ; and v_{it} is the error term, which is assumed to be normally distributed and uncorrelated with the regressors.

The conditions for identification require that at least one regressor is included in the probit estimation that affects selection into the sample but does not affect the price at which a property is sold. Furthermore, all regressors from the second step must be included in the first step too. A natural choice for the additional selection variable is the “valuation reserve”. We can think of the valuation reserve as a buffer with which the property is valued,¹⁵ i.e., the difference between the appraised value and the price that according to the market would be the appropriate one. From the perspective of the fund manager, it may be preferable to sell a property that is valued close to or below its market value in order to avoid a prompt reduction of portfolio value at the time a property is sold. In the case of open-end real estate funds, there even is the legally binding restriction that a fund is prohibited from selling below the latest appraised value. As a result, the fund manager has two choices: He may choose a property that fulfills this criteria priori (self selection), or he may try to influence the appraisal process so as to achieve an appraised value close to the expected sales price (client influence). We do not make any assumption about causality here, because we do not know whether the decision to sell affects valuation and/or prices, or whether properties are selected accordingly. In either way, the observed valuation reserve will be related to the sales probability. Yet, we do assume that the valuation reserve has no

¹⁴Actually, we only need the inverse Mills ratio for the sold properties.

¹⁵ In normal times, property valuations tend to be conservative. That is, on average there will be a slight undervaluation compared to what can be expected in the market.

effect on the buyer's reservation price and therefore on the price that can be achieved in the market (exclusion restriction). This assumption is crucial within the Heckman procedure, because we should use a variable that will help predict whether a property is sold, but at the same time is independent of the price that may be achieved in the market (Greene and Hodges 2002, pp. 196–197). Of course, in the absence of a reliable pricing model, we are not able to determine the exact amount of the valuation reserve. Thus, we derive a proxy by taking the difference between the predicted values from our combined sample naive hedonic model and the actual appraised value or transaction price.¹⁶ At least for the cross-section this gives us a good picture of which properties were over- or undervalued relative to each other.

Table 5 provides the results of the probit regression. The probit regression confirms that significantly more objects were sold during 2006 and 2007 than during any of the previous years (Specifications 1–3). Moreover, properties sold were predominantly large objects and open-end funds were among the more active sellers compared to other investors. Finally, a property's valuation reserve helped to explain whether a property was sold or not (Specifications 2–3), as the corresponding coefficient is positive and significantly different from zero, lending support to Hypothesis 2. Thus, the higher the valuation reserve, the more likely that a property was sold. Specification 3 finds no supporting evidence that this relationship is more pronounced for OEREFs compared to other types of investors, such as insurers and asset managers.

Table 6 displays the regression results for the first and second step of the Heckman procedure.¹⁷ The first step involves reestimating Specification 2 from our probit regression, while the second step includes the Selection Hazard derived from the first step as a further regressor.

In order to visualize the movement of prices over time we calculate predicted values for a representative property as in the previous section. Figure 2 displays the linear predictions for each period holding all property characteristics constant, as well as the 95 % upper and lower bound confidence interval.

Visual comparison of the results from the selection model to the naive hedonic index shows two very different pictures. Most strikingly, while in the naive model prices were still falling in 2006, the selection model shows an upswing in that year. Regarding the years prior to the crisis, the selection index displays a slight appreciation, while the naive model indicates that prices were falling during that time. Both show a positive development during 2002. However, the results should be viewed with caution as the confidence band of the index, based on the selection model, is relatively broad.

¹⁶This equals the predicted error from our hedonic regression for the combined sample.

¹⁷The sample size is reduced compared to the naive specifications, as we consider only valuation reserves within the boundaries of $\pm 25\%$

Table 5 Sales probability, Probit estimation

	(1)		(2)		(3)	
	SALE		SALE		SALE	
y99	-1.084***	(-13.17)	-1.077***	(-11.21)	-1.077***	(-11.21)
y00	-1.455***	(-14.85)	-1.452***	(-13.08)	-1.452***	(-13.09)
y01	-1.092***	(-14.71)	-1.076***	(-12.78)	-1.077***	(-12.77)
y02	-0.724***	(-11.17)	-0.714***	(-9.74)	-0.714***	(-9.75)
y03	-1.005***	(-13.72)	-0.994***	(-11.89)	-0.994***	(-11.89)
y04	-0.903***	(-13.29)	-0.863***	(-11.32)	-0.863***	(-11.33)
y05	-1.018***	(-14.26)	-0.940***	(-11.54)	-0.940***	(-11.53)
y07	0.188***	(3.57)	0.221***	(3.68)	0.221***	(3.68)
ln(quality)	-0.00300	(-0.02)	-0.0208	(-0.12)	-0.0189	(-0.11)
ln(rent)	-0.480***	(-5.09)	-0.493***	(-3.75)	-0.494***	(-3.75)
ln(age)	0.217***	(7.50)	0.172***	(5.25)	0.171***	(5.23)
ln(vacancy)	-0.288***	(-17.22)	-0.276***	(-14.12)	-0.276***	(-14.13)
ln(land)	0.0954**	(2.68)	0.121**	(2.68)	0.121**	(2.68)
ln(sqm)	-0.557***	(-5.45)	-0.556***	(-3.99)	-0.557***	(-3.99)
LARGE	0.154	(1.95)	0.212*	(2.47)	0.213*	(2.47)
SMALL	0.00579	(0.08)	-0.0231	(-0.27)	-0.0226	(-0.26)
MIXED	0.0454	(0.99)	0.0430	(0.83)	0.0428	(0.83)
ST	-0.306**	(-2.65)	-0.384**	(-2.87)	-0.384**	(-2.87)
BW	-0.104	(-1.01)	-0.171	(-1.41)	-0.170	(-1.40)
MU	-0.140	(-1.56)	-0.112	(-1.12)	-0.112	(-1.12)
BA	0.0314	(0.31)	0.0872	(0.76)	0.0884	(0.77)
BL	-0.0233	(-0.22)	-0.0347	(-0.29)	-0.0345	(-0.29)
BB	0.210	(0.68)	0.316	(1.01)	0.319	(1.02)
BR	0.0626	(0.44)	0.131	(0.79)	0.132	(0.80)
HH	-0.141	(-1.68)	-0.101	(-1.07)	-0.101	(-1.08)
HE	-0.0348	(-0.39)	0.0280	(0.27)	0.0289	(0.28)
MV	-0.0948	(-0.35)	-0.552	(-1.26)	-0.550	(-1.26)
NS	-0.171	(-1.56)	-0.0696	(-0.57)	-0.0686	(-0.56)
DU	0.0106	(0.12)	0.0341	(0.34)	0.0343	(0.35)
NW	-0.166	(-1.93)	-0.150	(-1.51)	-0.149	(-1.50)
KO	-0.0146	(-0.16)	0.0258	(0.25)	0.0264	(0.25)
RP	-0.321*	(-2.14)	-0.232	(-1.33)	-0.231	(-1.32)
SL	-0.174	(-0.88)	0.140	(0.62)	0.142	(0.63)
LP	0.419**	(2.80)	0.349	(1.88)	0.347	(1.86)
SS	-0.0323	(-0.17)	-0.0538	(-0.23)	-0.0547	(-0.23)
SA	0.278	(1.07)	0.417	(1.56)	0.415	(1.55)
SH	0.121	(0.84)	0.163	(1.02)	0.164	(1.03)
TH	0.153	(0.70)	0.174	(0.72)	0.173	(0.71)
OEREF	0.238***	(5.34)	0.212***	(4.30)	0.212***	(4.30)

Table 5 (continued)

	(1)		(2)		(3)	
	SALE		SALE		SALE	
Valuation reserve			1.128***	(5.96)	1.098***	(4.81)
OEREF*Val. reserve					0.0913	(0.23)
Constant	1.079*	(2.42)	0.988	(1.82)	0.985	(1.82)
Observations	15587		13271		13271	
Pseudo R^2	0.207		0.199		0.199	
AIC	5907.6		4575.1		4577.0	
BIC	6213.8		4882.3		4891.7	

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 5 displays the regression results for the probit estimation. The dependent variable is a dummy which indicates whether a property was sold (SALE=1) or not (SALE=0). The regressors are ln(Price/sqm): natural log of the transaction price per square meter; Y99-Y07: yearly dummies from 1999 to 2007; ln(Quality): ln of sustainable net income divided by area to let; ln(Rent) ln of rent divided by area to let; ln(Age): ln of economic age; ln(Vacancy): ln of vacancy rate; ln(Sqm): ln of area to let; ln(Land): ln of value of the build land; LARGE: 1 if a property belongs to the 10 % largest properties, 0 else; SMALL: 1 if a property belongs to the 10 % smallest properties, 0 else; MIXED: 1 if a property is combining retail and office use, 0 else; ST-TH: regional dummies; OEREF: 1 if a property belongs to an open-end fund, 0 else; Valuation reserve: percentage difference between the value predicted by the naive hedonic model and the actual appraised value or transaction price. The interaction term in Specification 3 is included to assess whether the valuation reserve has greater predictive power of the sales probability for OEREFs than for other investors.

Mass Appraisal

Rather than constructing hedonic price indices as in the previous sections, this section applies mass appraisal to individual properties. We calculate predicted values from the transaction-based models – both from the naive model and for the model controlling for selection bias – in order to establish a transaction-based benchmark to which we can compare actual appraised values. We start by calculating predicted values using coefficient estimates from Eq. 1 according to the following specification:

$$\hat{P}_{it} = \sum \hat{\alpha}_j^{tp} X_{ijt} + \sum \hat{\beta}_t^{tp} Z_t \quad (14)$$

While calculating predicted values from the naive model, based on OLS, is straightforward, there are several options to calculate predicted values from the selection model (Breunig and Mercante 2009). When we do not know whether or not a property was sold, the unconditional predictor gives the best estimate of the price. By contrast, if we know whether a property was sold or not we can condition on this information and use our model estimates to generate a conditional predicted price for properties being sold and not being sold, respectively. In our case it makes sense to

Table 6 Transaction price hedonic model, Heckman two-step

	(1) SALE		(2) ln(Price/sqm)	
y99	-1.077***	(-11.21)	-0.230***	(-9.53)
y00	-1.452***	(-13.08)	-0.367***	(-11.70)
y01	-1.076***	(-12.78)	-0.286***	(-11.56)
y02	-0.714***	(-9.74)	-0.162***	(-9.73)
y03	-0.994***	(-11.89)	-0.244***	(-8.41)
y04	-0.863***	(-11.32)	-0.283***	(-13.14)
y05	-0.940***	(-11.54)	-0.327***	(-12.34)
y07	0.221***	(3.68)	0.151***	(19.67)
ln(quality)	-0.0208	(-0.12)	0.943***	(35.68)
ln(rent)	-0.493***	(-3.75)	-0.0857***	(-4.20)
ln(age)	0.172***	(5.25)	0.00399	(0.50)
ln(vacancy)	-0.276***	(-14.12)	-0.135***	(-21.19)
ln(land)	0.121**	(2.68)	0.146***	(21.75)
ln(sqm)	-0.556***	(-3.99)	-0.118***	(-5.46)
LARGE	0.212*	(2.47)	0.118***	(9.24)
SMALL	-0.0231	(-0.27)	-0.0533***	(-3.66)
MIXED	0.0430	(0.83)	0.0227**	(2.60)
ST	-0.384**	(-2.87)	-0.132***	(-4.96)
BW	-0.171	(-1.41)	-0.0487*	(-2.33)
MU	-0.112	(-1.12)	-0.0316*	(-1.97)
BA	0.0872	(0.76)	0.0145	(0.75)
BL	-0.0347	(-0.29)	-0.00361	(-0.24)
BB	0.316	(1.01)	0.260***	(5.29)
BR	0.131	(0.79)	0.00943	(0.40)
HH	-0.101	(-1.07)	0.00100	(0.07)
HE	0.0280	(0.27)	-0.00286	(-0.19)
MV	-0.552	(-1.26)	-0.173***	(-6.02)
NS	-0.0696	(-0.57)	-0.0293	(-1.52)
DU	0.0341	(0.34)	0.0405**	(2.88)
NW	-0.150	(-1.51)	-0.0562***	(-3.35)
KO	0.0258	(0.25)	0.0151	(0.85)
RP	-0.232	(-1.33)	-0.113***	(-4.56)
SL	0.140	(0.62)	-0.00876	(-0.30)
LP	0.349	(1.88)	0.149***	(5.70)
SS	-0.0538	(-0.23)	-0.00483	(-0.15)
SA	0.417	(1.56)	0.263***	(3.76)
SH	0.163	(1.02)	0.0561	(1.93)
TH	0.174	(0.72)	0.123**	(2.84)

Table 6 (continued)

	(1)		(2)	
	SALE		ln(Price/sqm)	
OEREF	0.212***	(4.30)	0.164***	(16.08)
Valuation reserve	1.128***	(5.96)		
Selection hazard			1.203***	(23.97)
Constant	0.988	(1.82)	3.055***	(22.75)
Observations	13271		722	
AIC	4575.1		-1557.1	
BIC	4882.3		-1373.8	

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 6 displays the regression results for the first and second step of the heckman procedure. In the first step, we estimate the probability that a property is sold using a probit model. In the second step, information on the sales probability (the non-selection hazard) is included in the hedonic transaction price regression to control for the fact that a property had been sold in the first place.

ln(Price/sqm): natural log of the transaction price per square meter; Y99-Y07: yearly dummies from 1999 to 2007; ln(Quality): ln of sustainable net income divided by area to let; ln(Rent) ln of rent divided by area to let; ln(Age): ln of economic age; ln(Vacancy): ln of vacancy rate; ln(Sqm): ln of area to let; ln(Land): ln of value of the build land; LARGE: 1 if a property belongs to the 10 % largest properties, 0 else; SMALL: 1 if a property belongs to the 10 % smallest properties, 0 else; MIXED: 1 if a property is combining retail and office use, 0 else; ST-TH: regional dummies; OEREF: 1 if a property belongs to an open-end fund, 0 else; Valuation reserve: difference between the value predicted by the naive hedonic regression and the actual appraised value or transaction price.

condition on the property not being sold, since this is exactly the sub-sample we are considering. Thus, we calculate predicted values for the appraised properties:

$$\hat{P}_{it} = E[P_{it} | S_{it}^* = 0] = \sum \hat{\alpha}_j X_{ijt} + \hat{\beta}_t + \hat{\sigma}_{\varepsilon\eta} \lambda_{it},$$

$$\text{where } \lambda_{it} = \frac{-\phi \left[\sum \hat{\omega}_j X_{ijt} + \sum \hat{\gamma}_t Z_t - \sum \hat{\delta}_j H_{ijt} \right]}{1 - \Phi \left[\sum \hat{\omega}_j X_{ijt} + \sum \hat{\gamma}_t Z_t - \sum \hat{\delta}_j H_{ijt} \right]} \quad (15)$$

In the following step, we use those predicted values in order to compare them with the actual appraised values. For each property in our sub-sample, we calculate the percentage deviation of the predicted hedonic price to the appraised value, each for the predictions based on the naive as well as the Heckman model:

$$\hat{D}_{it} = \left(\frac{\hat{P}_{it}}{V_{it}} - 1 \right) * 100, i \in \text{appraised values} \quad (16)$$

Although deviations at the individual property level might be noisy, this measure allows us to gain valuable insight on the patterns of valuation differences. We are able to directly assess whether the mean error varies over time and whether there is a systematic difference between open-end real estate funds and other investors

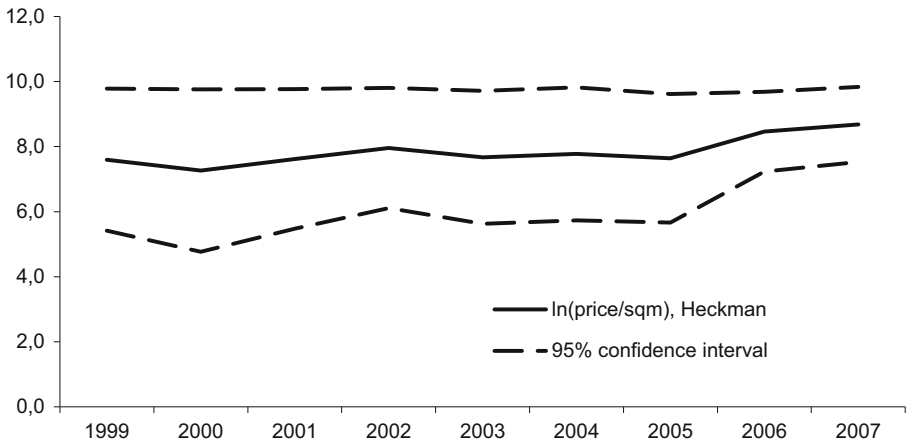


Fig. 2 Transaction price hedonic index – selection model. Figure 2 displays the hedonic transaction price index derived, i.e., linear predictions from the Heckman regression holding the hedonic factors constant. The dotted lines represent the 95 % upper and lower bound confidence interval around the point estimates

regarding the deviation from hedonic prices. Figures 3 and 4 display the weighted average of the prediction errors for OEREFs and non-OEREFs, respectively. Tables 7 and 8 provide the corresponding data in tabulated form, including standard deviations and confidence intervals.

Both figures show that appraised values on average were significantly exceeding the hedonic transaction prices some time prior to the crisis – lending support to Hypothesis 1, i.e., that the open-end fund crisis of 2005/2006 was preceded by a

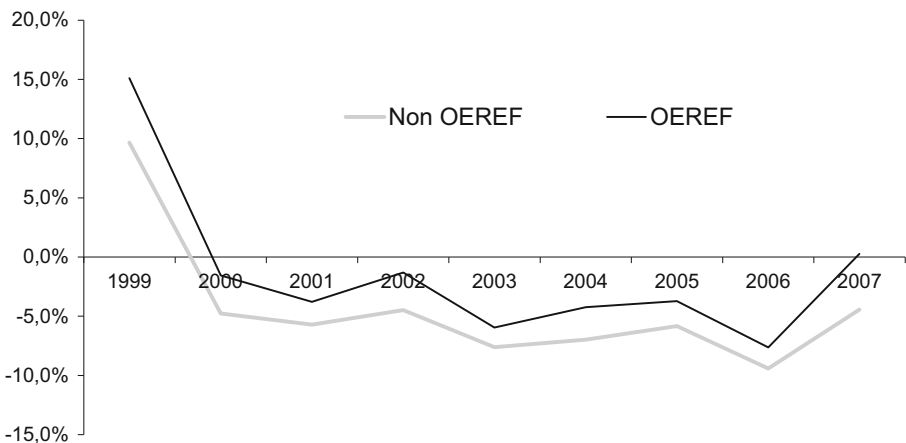


Fig. 3 Difference between appraised value and hedonic price – naive model. Figure 3 displays the weighted average of the percentage differences between (i) predicted values for the properties held using Eq. 14, i.e., the naive hedonic transaction price model, and (ii) the actual appraised values. The weighted averages are calculated for the years 1999 to 2007 and for OEREFs and non-OEREFs, respectively. Table 7 provides the corresponding data in tabulated form including standard deviations and confidence intervals

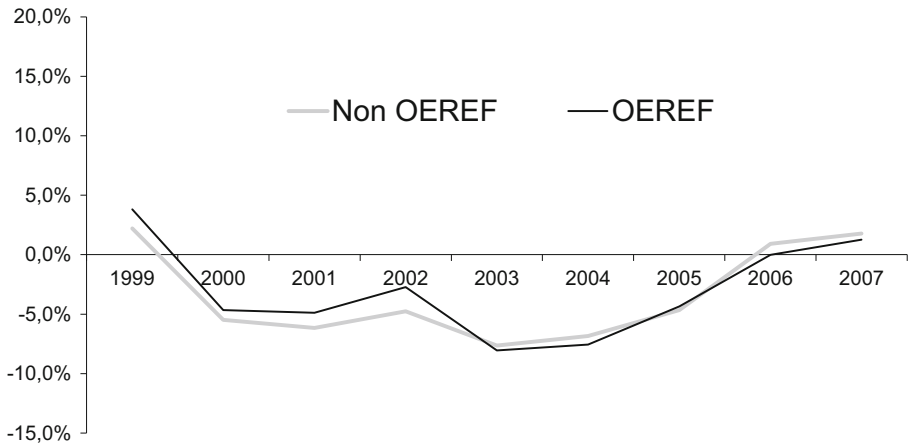


Fig. 4 Difference between appraised value and hedonic price – selection model. Figure 4 displays the weighted average of the percentage differences between (i) predicted values for the properties held using Eq. 15, i.e., the selection hedonic transaction price model conditional on the property being hold, and (ii) the actual appraised values. The weighted averages are calculated for the years 1999 to 2007 and for OEREFs and non-OEREFs, respectively. Table 8 provides the corresponding data in tabulated form including standard deviations and confidence intervals

Table 7 Deviations of naive hedonic price from appraised value

	All years	1999	2000	2001	2002	2003	2004	2005	2006	2007
Non OEREF										
Mean	-5.5 %	9.7 %	-4.8 %	-5.7 %	-4.5 %	-7.6 %	-7.0 %	-5.8 %	-9.4 %	-4.4 %
StDev	0.2 %	0.6 %	0.4 %	0.4 %	0.4 %	0.4 %	0.4 %	0.4 %	0.5 %	0.4 %
Upper bound	-5.2 %	10.8 %	-3.9 %	-4.9 %	-3.7 %	-6.8 %	-6.2 %	-5.1 %	-8.5 %	-3.6 %
Lower bound	-5.8 %	8.5 %	-5.6 %	-6.6 %	-5.3 %	-8.5 %	-7.7 %	-6.6 %	-10.3 %	-5.3 %
Obs.	6364	362	731	730	770	781	875	879	610	626
OEREF										
Mean	-3.0 %	15.1 %	-1.6 %	-3.8 %	-1.3 %	-6.0 %	-4.2 %	-3.7 %	-7.6 %	0.3 %
StDev	0.2 %	0.6 %	0.5 %	0.5 %	0.5 %	0.4 %	0.5 %	0.5 %	0.5 %	0.6 %
Upper bound	-2.6 %	16.3 %	-0.6 %	-2.8 %	-0.4 %	-5.1 %	-3.3 %	-2.8 %	-6.6 %	1.5 %
Lower bound	-3.3 %	13.9 %	-2.5 %	-4.7 %	-2.2 %	-6.8 %	-5.1 %	-4.7 %	-8.6 %	-1.0 %
Obs.	4362	233	542	537	570	572	584	594	420	310

Table 7 displays summary statistics of the differences between actual appraised values and hedonic prices as predicted by the naive hedonic model. A negative mean value indicates that actual appraised values were on average higher than the hedonic price predicted, and vice versa. The upper and lower bounds mark the 95 % confidence interval around the mean value.

Observations one year prior to a sale, the year following a sale year, as well as the year of the sale itself are excluded from the sample.

Table 8 Deviations of Heckman hedonic price from appraised value

	All years	1999	2000	2001	2002	2003	2004	2005	2006	2007
Non OEREFs										
Mean	-5.1 %	-2.0 %	-8.9 %	-7.7 %	-4.7 %	-9.9 %	-7.8 %	-7.8 %	-1.8 %	1.8 %
StDev	0.1 %	0.5 %	0.4 %	0.4 %	0.3 %	0.4 %	0.4 %	0.4 %	0.3 %	0.3 %
Upper bound	-4.8 %	-1.0 %	-8.1 %	-7.0 %	-4.0 %	-9.2 %	-7.0 %	-7.0 %	-1.2 %	2.3 %
Lower bound	-5.4 %	-3.0 %	-9.8 %	-8.5 %	-5.3 %	-10.6 %	-8.5 %	-8.5 %	-2.3 %	1.3 %
Obs.	6222	524	600	686	721	756	749	749	797	664
OEREFs										
Mean	-4.1 %	-0.6 %	-6.8 %	-5.3 %	-3.5 %	-4.7 %	-9.2 %	-6.3 %	-1.6 %	2.2 %
StDev	0.2 %	0.5 %	0.5 %	0.4 %	0.4 %	0.5 %	0.4 %	0.5 %	0.3 %	0.3 %
Upper bound	-3.8 %	0.4 %	-5.8 %	-4.5 %	-2.7 %	-3.8 %	-8.4 %	-5.4 %	-1.0 %	2.9 %
Lower bound	-4.4 %	-1.6 %	-7.8 %	-6.1 %	-4.3 %	-5.6 %	-10.0 %	-7.2 %	-2.2 %	1.6 %
Obs.	4140	467	407	505	543	515	444	429	506	324

Table 8 displays summary statistics of the differences between actual appraised values and hedonic prices as predicted by the heckman model. A negative mean value indicates that actual appraised values were on average higher than the hedonic price predicted, and vice versa. The upper and lower bounds mark the 95 % confidence interval around the mean value.

Observations one year prior to a sale, the year following a sale year, as well as the year of the sale itself are excluded from the sample.

systematic divergence of prices observed in the market relative to appraised values. However, the timing of valuation differences seems to differ between the two estimation methods. While simple OLS yields the biggest negative gap (i.e. overvaluation) during the year 2006, valuation differences almost disappear during this very period when we account for possible selection biases. Such outcome is consistent with anecdotal evidence indicating that prices were already rising again during 2006, while appraisal-based values had not yet adjusted to the previous fall in market values. Figure 1 supports this view, showing that funds were further devaluing their portfolios between 2006 and 2007, at a time when market prices were supposedly rising again. Ultimately, our analysis yields no significant differences of valuation accuracy between open-end funds and other investors. Thus, we cannot support Hypothesis 3, i.e. that valuation differences were more pronounced for OEREFs compared to other investors.

Conclusions

This paper set out to explore whether systematic deviations of appraised values from prices achieved in the market could have been a cause for the 2005/2006 German open-end fund crisis. To this end, we analyzed a distinct sample of German office properties held and sold by institutional investors between 1999 and 2007. In the

market considered, rationally restricted sellers – open-end real estate funds and other institutional investors relying on expert appraisals – stand vis-à-vis unrestricted buyers, assumed to pursue hedonic pricing. As a result, we observe transactions only if prices achieved in the market are above or close to the appraised values. Using mass appraisal, based on a selection model to account for possible biases, we compare hedonic prices to actual appraised values. This approach represents an innovation to the current literature on valuation accuracy in real estate markets.

For a 5-year period preceding the 2005/2006 crisis, we find that properties held were overvalued relative to the prices that were achieved in the market. Lending support to the hypothesis of sellers being reluctant to sell below appraised values, properties *sold* were generally valued closer to the market than properties *held*. Albeit open-end funds operating under a special institutional regime, divergence of appraisal-based values from actual transaction prices appears to be a general phenomenon during the period considered and not confined to open-end real estate funds.

The findings yield important policy implications, which promise to provide additional impetus to the current regulatory debate. In particular, the findings lend support to the notion that German open-end real estate funds resemble deposit taking institutions rather than common mutual funds in at least one further aspect: In addition to providing liquidity transformation, they offer a return which displays much lower volatility than that of the underlying assets. Although open-end real estate fund contracts are effectively and legally based on the principles that govern mutual funds – where fund shares represent residual claims on the funds' assets – true asset value may deviate from face value promised to fund investors. In rising markets, this allows funds to accrue hidden reserves, while in bad times – as we have shown – funds may accumulate substantial hidden losses. In addition to the purely speculative run in the tradition of Diamond and Dybvig (1983), the current valuation practice of open-end funds thus provides for the possibility of an information-based run as described by Jacklin and Bhattacharya (1988) or Allen and Gale (1998).

In order to reduce the possibility of information-based runs, funds may pursue three alternative routes. First, funds may transform into a closed-end form by restricting the redemption of fund shares, while introducing a secondary market for them.¹⁸ This would leave investment in the funds exposed to the volatility of the market comparable to that of a real estate investment trust (REIT). Second, funds could aim at striking a more robust balance between the objectives of stable returns and daily redeemable shares by improving on the current valuation practice. To this end, funds should be required to improve current valuation practices by introducing more frequent valuations and/or placing greater emphasis on market signals within the valuation process. Third, regulators should recognize the fact that open-end real estate funds resemble deposit-taking institutions to the extent that they provide liquidity transformation, and that they promise to some degree a smoothed payout in the light of volatile markets. After all, the possibility of appraised values deviating from

¹⁸For instance, the Swiss model confines share redemptions to the end of the calendar year, in addition to having a one year notice period.

market assessments may not be a bad thing per se, as investors might value the smoothing of returns; which may be socially beneficial (see Allen and Gale 1998, Sebastian and Tyrell 2006). In this case, however, one should consider asking the funds to provide two distinct contracts similar to what banks provide: a fund deposit share, offering a relatively stable return and redeemable on a daily basis; and a pure equity share, which can serve as an additional capital buffer in the light of fluctuating asset prices. Of course, an additional premium would have to be paid to equity investors, which in turn would lower the ex ante returns of depositors. Under the current regulatory regime, open-end real estate funds are considered mutual funds and depositors pay the premium ex post – if and only if a crisis hits.

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