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Value Drivers and Valuation Algorithms of Residential Investments

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Abstract

This paper presents the results of two valuation functions of residential investments properties in Berlin, Germany and thus the influencing factors on the price of these properties. With their assistance, house prices are predicted, which take into account the heterogeneous features of residential properties. The estimation procedure uses multiple regression models, so-called hedonic models. These hedonic models evaluate properties based on their intrinsic values and determine the overall value from their distinguishing characteristics. The focus is on multi-dwelling units [i.e. 'houses in multiple occupation [HMOs], multiple-family dwellings, etc.] and rented condominiums, which is to say classical investment properties that are typically appraised using the income approach or the discounted cash flow method [DCF method]. Sales comparison approaches such as the hedonic method are considered to be more appropriate for property valuation due to their closeness to the market and reduced possibility of subjective approaches. With digitisation, automated valuation procedures have become more important and also enabled alternative methods that require less costs, effort and subjectivity for the appraiser. In this Paper, the question is addressed as to whether or not a valuation algorithm for estimating market prices by means of statistical methods is also applicable for real estate investments.

Keywords: residential properties; automatic valuation; house prices; investment real estate; data science.

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1. Introduction

In light of increasing rents and prices, the continuing low interest rate environment and a lack of profitable or secure investment alternatives for investors, residential real estate continues to be one of the most preferred asset classes [3,4] in Germany. Particularly in Berlin, one of the most dynamic cities in Germany, further price increases can be expected due to the persistent excess demand for rental flats. The population and economic output have been increasing continuously for many years, and the need for housing with it. The value of these residential investments is of great interest to investors both on the level of an individual property and on the portfolio level. The valuation does not only take place for the purpose of the transaction, but also for financing or accounting with potentially considerable financial consequences [23]. With regard to the respective purpose of the valuation and the desired depth of information, there are different approaches to real estate valuation, especially in portfolio valuation [45]. Mass valuations are also the focus of current discussions in terms of benefits and effort/expenditures. For example, until the upcoming property tax reform is implemented in 2025, all properties in Germany will have to be reappraised by 2022. Valuations of large real estate holdings entail a significant time and cost factor. Economic considerations with regard to the costs of the valuation and the required quality of the valuation results often determine the method used [45]. As part of the portfolio valuation, the real estate portfolio in the narrower sense must be distinguished from the portfolio in the broader sense. According to the theory of Markowitz [26, 27], the real estate portfolio in the narrower sense is specifically comprised of risk-return considerations, and the investor acts on a purely rational basis to maximise the profits [21]. The portfolio in the broader sense is to be understood as a totality of real estate, which is characterized neither by a certain structure nor by a conscious risk-return choice. It is only characterized by a precisely defined number of properties that are subject to uniform administration or uniform management or are assigned to an owner [45, 46]. In addition to generalised and structured appraisal methods, individual valuations are also regularly utilised at the portfolio level. The value of the overall portfolio is not determined by taking into account so-called compound effects, i.e. package surcharges or discounts, rather by the sum of the individual values within the portfolio [45]. The valuation of portfolios usually occurs at the level of aggregated individual values for investment properties using the DCF method or the income capitalization approach to valuation. The risk associated with the respective property is primarily represented by the discounted rate, whereby the respective appraiser has the appropriate scope to apply the discounted rate and the other value-creating parameters [32]. The valuation results vary considerably even with small changes in the discounted rate. By means of so-called comparables, if available, these valuation results are substantiated or checked for plausibility, whereby also the selection of comparables is not free of subjectivity [5].

2. Automated Valuation Models – Literature Review

Alternative or supplementary valuation methods, in particular Automated Valuation Models [AVMs], are increasingly the subject of current research projects [8, 9, 12, 19, 32, 36, 43, 49]. Of course, new techniques alone do not guarantee better valuation results; also here, the result depends primarily on the information available to the appraiser [22]. Nevertheless, automated processes are promising as a cost-saving valuation alternative [36]. Germany does not have a comprehensive data infrastructure that can be used as the basis of mass real estate valuation. Rather, the regional committees of valuation experts have more or less effective

systems whose databases have already been used for individual automated valuations [34, 37, 47]. The most commonly used automated valuation models include the OLS regression [ordinary least squares] with the logarithmic house price and property variables to describe the location and the building specifics [1, 7, 25, 36, 39, 44]. Studies show that real estate values are often overestimated [5, 15]. Therefore, accuracy and volatility are also the focus of the analyses with AVMs [5, 28]. The valuation of land by means of OLS regression is also known as hedonic valuation methods [10], whereby the spectrum of possible uses of hedonic methods is also very diverse. In addition to the index construction [42] and the analysis of one or more factors influencing the target figure purchase price or rent [18, 29, 38], hedonic models [among others] are also used to identify product or geographic submarkets [11, 16] or to analyse the demand for specific building properties [16, 40, 41]. From an economic point of view, the hedonic price method is based on Lancaster's [20] consumer theory, in which the individual characteristics of an asset are beneficial. Lancaster [20] and Rosen [31] made important contributions to hedonic price theory, which was further developed at the microeconomic level. With Lancaster, a linear relationship is ultimately assumed between the price of the asset and the properties of that asset. Rosen's model, on the other hand, assumes a non-linear relationship between the price of the asset and its properties. The specification of a hedonic model requires not only the selection of the correct functional form, but also the definition of the submarket to be examined, the selection of the target figure and the determination of the price-determining independent variables [33]. The hedonic theory gives no indication of the form of the price function [25]. The views differ as to whether classical OLS regression or other or expanded models are better suited for property valuation [5, 8, 28]. Robust methods have proven to be suitable methods in connection with certain data problems such as heteroscedasticity outliers or not normally distributed data [6, 30]. Ultimately, the valuation results largely depend on the quality of the data and the statistical effort required. According to Bogin and Shui [5], classical hedonic regression is an excellent method compared to AVMs. It will be presented in this paper as a statistical comparative-value method for investment properties. The focus is on two valuation functions for multi-dwelling units and for rented condominiums. Taking into account the heterogeneous characteristics of residential real estate, market prices are estimated to be on the level of an individual property. The question as to whether a valuation algorithm for estimating market prices using statistical methods, e.g. for mass valuation on the level of an individual property, is also possible for investment properties is addressed. Based on estimation accuracy, the models are then evaluated, including the possibility of portfolio valuation.

3. *Materials and Methods*

3.1. Descriptive statistics of the samples

The following descriptive statistics refer to the two samples that were used for the valuation functions of the multi-dwelling units and the rented condominiums. The area examined is the city of Berlin, whereby the purchase price collection of the Committee of Valuation Experts in Berlin serves as a database for the transactions made. The complete data set contains all observations, with the exception of those that showed irregularities or for which the essential explanatory variables such as the net cold rent [excluding electricity/heating costs] or living space were missing. Additionally, duplicates were taken into account, i.e. de facto double counts, which had to be eliminated.

Table 1: Samples for residential investments Source: own calculation

Sample	Rental multi-dwelling units	Condominiums
Sample [completion data set]	4,370 [100%]	10,973 [100%]
Sample [after correcting for outliers]	4,330 [99.3%]	10,892 [99.3%]
Observation period	1993-2018	2011-2017

The regional representativeness of the samples used was checked by comparing them with the transactions recorded by the Committee of Valuation Experts in Berlin. According to § 193 BauGB, its core tasks include the collection, management and evaluation of purchase prices for all transactions made. Table 2 depicts the observation distribution by district for the respective observation period of the samples. The comparison of the sample share by district for the multi-dwelling units [MDU] and condominiums [CDO] shows an approximately equal distribution of the samples for the transactions made.

Table 2: Comparison of the samples with the actual transactions Source: own calculation

District	Rental multi-dwelling units		Condominiums	
	Share Sample	Share Transactions	Share Sample	Share Transactions
Mitte	16,5%	16%	12,0%	11,0%
Friedrichshain-Kreuzberg	12,7%	12,9%	12,1%	9,8%
Pankow	12,3%	14,3%	14,5%	12,9%
Charlottenb.-Wilm.	9,6%	9,0%	12,9%	15,9%
Spandau	6,5%	5,4%	3,5%	5,1%
Steglitz-Zehlendorf	6,6%	8,4%	5,8%	7,3%
Tempelhof-Schöneberg	12,9%	10,3%	14,3%	13,7%
Neukölln	6,8%	5,6%	5,8%	8,0%
Treptow-Köpenick	3,9%	4,7%	5,3%	5,6%
Marzahn-Hellersdorf	1,1%	1,8%	0,5%	0,7%
Lichtenberg	4,1%	6,1%	7,1%	4,2%
Reinickendorf	7,1%	5,5%	6,1%	5,8%

Transactions over a period of 25 years, from 1993 to 2018, are the basis of the estimate for the valuation function of the multi-dwelling units. For the condominiums, purchases from 2011 to 2017 were collected and used as the basis for the estimate. The typical MDU was sold at a median price of approximately EUR 900,000 and an average price [mean] of approx. 1.5 million Euros. The CDO median price is EUR 100,000, with an average purchase price of EUR 122,124. On average, the price for an MDU in Berlin was EUR 1,037 per sqm with a standard deviation of EUR 649 per sqm. The average price for rented condominiums is EUR 1,833 per sqm and fluctuates around the mean at EUR 733 per sqm.

Table 3: Analysis of the MDU Sample Source: own calculation

	10% Quantile	90% Quantile	Median	Mean
Transaction Price [EUR]	319.652	3.023.136	899.271	1.534.347
Transaction Price per sqm [EUR]	430	1.905	864	1.037
Net cold rent per square meter [EUR]	2,78	7,40	4,87	4,99
Living space per square meter.	386	2.383	964	1.488
Plot area per square meter	404	2.201	807	1.467
land value per square meter [EUR]	200	869	409	516
Year of construction	1889	1986	1920	1932

Table 4: Analysis of the CDO Sample Source: own calculation

	10% Quantile	90% Quantile	Median	Mean
Transaction Price [EUR]	54,000	210,000	100,000	122,124
Transaction Price per sqm [EUR]	1.052	2.817	1.696	1.833
Net cold rent per square meter [EUR]	4.81	8.97	6.24	6.62
Living space per square meter.	39,26	91,10	61,59	64,63
Plot area per square meter	657	16,150	2,321	5,631
land value per square meter [EUR]	200	1,500	455	671
Year of construction	1900	1995	1935	1941

Section 3 shows the respective average prices, their fluctuations around the mean and the respective medians for both samples. On this basis, a quite skewed distribution of the samples is already apparent. The distribution around the mean is relatively large and illustrates how the purchase prices tend to concentrate rather slightly around the mean. The purchase prices are not normally distributed, which is also not a prerequisite [35], but it is cheaper. The skew of the data distribution can be significantly reduced using first aid transformation [23] with the natural logarithm, which also has a positive effect on the distribution of the residuals [23, 24]. Initially, the model remains additive in the coefficients, however the effect is multiplicative, i.e. the purchase price changes proportionally. The transformation of the purchase price is not only statistically recognisable, but also confirms the hedonic model theory, according to which the price cannot be derived linearly.

3.2. Model estimation

All purchase prices are described in more detail by means of additional survey characteristics with their respective characteristic values. The survey characteristics can be divided into four categories. The first category serves to clearly identify the respective purchase case in the purchase price collection and contains, among other things, the time of transaction. The second category describes the exact location of the respective sale properties. This includes the exact property address in the respective district. In addition, variables such as the urban residential area, the district-typical construction, the land standard, the typical number of storeys based on the land standard, the typical and price-determining type of use or the block location of the property are described.

In the third category, the individual property characteristics are given, variables such as: year of construction, living space, floor area, number of residential units or the condition of the properties. The last category includes profitability such as net cold rent, etc. The following table 6 provides an overview of the explanatory variables of the MDU estimation function. The reference category refers to multi-dwelling units located in a simple residential area, built before 1919 [yclass1], with central or multi-storey heating, the average state of the building, the Mitte district and the transaction year 2008. The estimate was made using the OLS method, in which the dependent variable total purchase price was transformed using the natural logarithm. The explanatory categorical variables are taken into account via dummy variables, non-linear influences of the metrically scaled variables through their corresponding conversion [33]. The results of the estimation function for multi-dwelling units can be found in Table 8.

Source: own calculation

Table 6: Explanatory variables of the valuation function for rental multi-dwelling units

Variable	Code	Description
Year of transaction	1993-2018	Dummy for Calendar year of the transaction
Construction-year class	yclass1-yclass7	Dummy for Construction-year class
Heating type	HeatingOther	Dummy for buildings without central/floor heating
Building condition	Building state good or poor	Dummy for deviating building condition "middle"
Actual floor space index	FSI	Actual floor space
Living and usable space	LVS	Total living and usable space of the residential building
Residential units	Units	Number of residential units
Urban residential area	Middle, good, very good URA	Dummy for deviating urban residential area "simple"
Land value	Land value	Ascertained land value prior to the contract date
District	District name	Respective district where the transaction took place
Plot area	Plot	Total plot area
Net cold rent per square metre	Net rent	Average net cold rent per square metre of living space
Location*condition	InterResiAreaBuilStateGood	Interaction term between location and condition

Like MDU, the influencing variables of condominiums can also be divided into the four categories of identification, location, property characteristics and profitability. The following table 7 also provide an overview of the exogenous variables. The results of the econometric tests of the valuation function for CDO are shown in table 8. The reference category refers to CDO in a simple residential area in the Mitte district, built before 1919 [yclass1], with central or floor heating, to small property sizes [max. 20 residential units], with kitchen, balcony,

lift and cellar, without garage, located on the ground floor as well as to the transaction year 2011. Regressand and predictor variables were transformed similarly to the valuation function for MDU.

4. Results and Discussion

4.1. Assessment of the valuation functions

In addition to the model parameters, the asset values also provide important information for making credible statements about the assets and reliability of the models. The coefficient of determination [also R^2] measures the share of the variance of the variables [of the purchase price], which is explained by the regression. R^2 increases automatically with each additional regressor that is added, so the corrected coefficient of determination [R^2 adj] is given. Both valuation functions show approx. 89% [MDU] or 82% [CDO], a very good adjustment in relation to the influence of property quality on the purchase price [14, 48]. The significance of the overall model, i.e. whether the dependent variables have explanatory power, is tested using the F statistic [2, 13].

Table 7: Explanatory variables of the valuation function for condominiums Source: own calculation

Variable	Code	Description
Transaction year	2011-2017	Dummy for Calendar year of the transaction
Construction-year class	yclass1-yclass7	Dummy for Construction-year class
Heating type	HeatingOther	Dummy for buildings without central/floor heating
Living space	LVSUnit	Total living space of the residential unit
Property size	OGmiddle; OGlarge	Dummy for deviating property size 'small'
Kitchen	No kitchen	Dummy for no Kitchen
Balcony	No balcony	Dummy for no Balcony
Garage	Garage available	Dummy for Garage available
Lift	No lift	Dummy for no lift
Cellar	No cellar	Dummy for no existing cellar regarding the unit
Residential location	LaOG-LaUG	Dummy for different ground floor location of the flat
Urban residential area	middle, good, very good URA	Dummy for deviating urban residential area "simple"
land value	land value	Ascertained land value prior to the contract date
district	district name	Respective district where the transaction took place
plot area	Plot	Total plot area
Net cold rent per square metre	net rent	Average net cold rent per square metre of living space

Both models are also highly significant here, i.e. the observed correlations are not just random, and all variables included provide a common explanatory contribution to the market price. In addition, in both valuation functions, all the coefficients of the estimated model parameters, with the exception of a few dummy variables in relation to their reference category, are highly significant, differ from zero and prove to be economically viable with regard to their respective indications.

Table 8: Results of the estimation function Source: own calculation

Estimation function for	MDU		CDO	
R2	0.8883		0.8201	
R2adj	0.8869		0.8194	
S.E. of regression	0.3038		0.2307	
F-Test	597.58	***	1177.56	***
Number of observations	4,339		10,892	

***Signif. < 0.001; **Signif. < 0.01; *Signif. < 0.05; ◦ Signif. < 0.10

The residuals contain the residual distribution of the data that is not explained by the variables and thus allow statements to be made about the reliability of the results and the accuracy of the valuation functions [13]. Whether the residuals are evenly distributed around zero is verified. The results of the residual analysis of the valuation functions, exemplary for MDU in Figures 2, show that the residuals follow approximately a normal distribution and are not distributed in a long tail. The scatter diagram, which shows the estimated values versus the residuals, also checks for normality, heterogeneity of variances and outliers [24, 35]. The residuals are distributed randomly and balanced around the zero line; the variance of the residuals is constant. The possible existence of autocorrelation was checked using the Durbin-Watsen statistic and can be rejected for both models with values of d = 1.8 [MDU] and d = 1.7 [CDO]. The independence of the residuals is given [2]. The variance inflation factor [VIF] for all variables is below five for both models, which also does not substantiate the suspicion of multicollinearity [13].

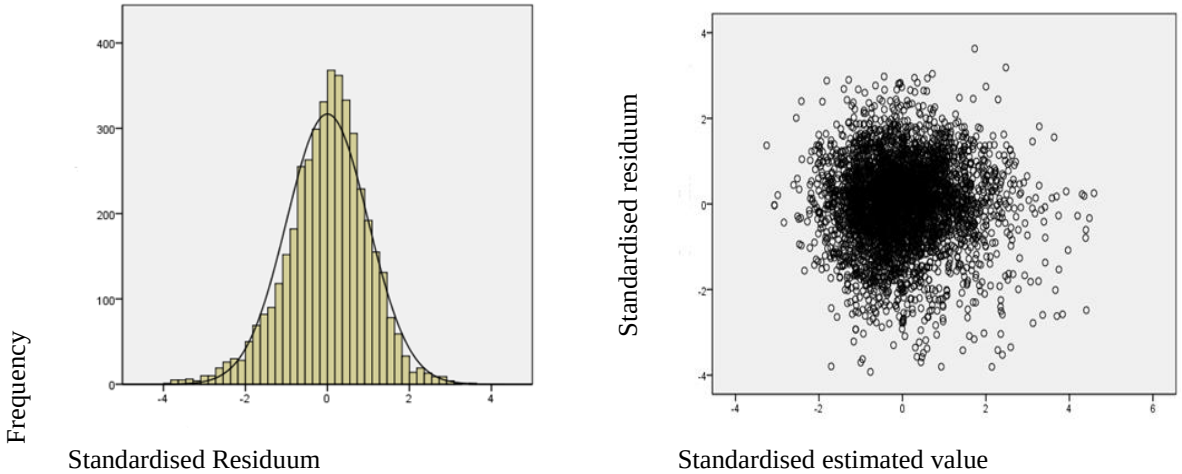

Figure 2: Residuals MDU Source: own calculation

4.2. Explanatory variables

The variable net cold rent has the greatest influence on the purchase price for both functions. This corresponds to the actual [contractually agreed] rent at the time of the transaction. This variable is entered into the model as a polynomial, i.e. the price increases as the rent increases, but falls again once a certain rent is reached. The contractually agreed rent plays a central role in the assessment of the purchase price by an investor. If it differs from the market rent, e.g. if it is below the market rent [underrent], possible rent increase potentials are already positively taken into account in the calculation of the purchase price. On the other hand, an overrent represents a risk of achieving this in the long term and no further rent increases are possible, which tends to have a negative impact on the purchase price. Both models cannot take into account of either overrent or underrent. Another major influencing factor is the vacancy rate at the MDUs at the time of the transaction. Generating additional income from vacant space after the purchase of the property is usually positively reflected in the purchase price. The influence of vacancies, possible property subsidies or the expected management costs are not taken into account in the model, although a significant influence is expected here. However, in the present models, the use of external data was deliberately avoided in order to check the validity and applicability of the original data. The influence of land value and size on the purchase price of MDU can be interpreted as elasticity by transformation with the natural logarithm. Since the coefficients are < 1.0, the marginal increase of the purchase price decreases with increasing land value and land size, which expresses the decreasing marginal yield [2]. Rising land values thus also reflect the increasing earning power of the land, which in turn is not infinite. Also the increasing positive influence of the plot size on the purchase price reaches a saturation point, oversized plots no longer contribute significantly to the generation of higher rental income. The variable living space has a further significant influence on the purchase price for both MDUs and CDOs. In the case of rented condominiums, this variable enters the model as an inverse, i.e. the purchase price decreases with increasing living space. Small and average sized apartments are much easier to let, which is also reflected in the purchase price. The situation is similar for apartment buildings. The prices fall with increasingly large-volume residences.

4.3. Estimation accuracy

Table 9: Relative deviation of the estimated values [excl. outliers] Source: own calculation

	Multi-dwelling units			Rented condominiums		
	Actual purchase price	Estimated value		Actual purchase price	Estimated value	
10.00%-Quantile	319,652	352,771	[10.4%]	54,000	57,443	[6.4%]
30.00%-Quantile	577,980	598,642	[3.6%]	77,600	79,084	[1.9%]
50.00%-Quantile	899,271	879,953	[-2.1%]	100,000	99,223	[-0.8%]
70.00%-Quantile	1,449,168	1,371,620	[-5.4%]	136,000	131,013	[-3.7%]
90.00%-Quantile	3,023,136	2,872,986	[-5.0%]	210,000	196,866	[-6.3%]

The estimation accuracy of both valuation functions is good. Table 9 shows the distribution of the relative deviation of the estimated market prices from the actual purchase prices. Lower prices in both functions tend to be overestimated, and higher purchase prices are typically underestimated. In the 10% to 90% quantile of the predicted values [80% of the estimated values], the hedonic prices for an individual property for both types of use do not deviate by more than 20% from the actual purchase prices. Across the entire portfolio, the estimated hedonic values deviate from the actual purchase prices by -2.8% [MDU] and -2.7% [CDO] as shown in table 10.

Table 10: Relative deviation on the portfolio level [excl. outliers] Source: own calculation

Portfolio level	Sum of purchase prices	Sum of estimates	Diff. in %	Trend
MDU	6,657,529,647	6,469,208,330	-2.8%	undervalued
CDO	1,330,176,019	1,294,748,581	-2.7%	undervalued

The previously estimated valuation functions can be used for prediction purposes. The starting point is the assumption of hypothetical relationships between purchase price and the explanatory variables, which are formulated in a hedonic model. For this, the econometric structure with the best economic plausibility and the best statistical criteria was selected. The prerequisite is a certain constancy of this structure and the given values of the explanatory variables for the comparable prices that are to be predict. Comparative prices for specific valuation properties can be generated with the valuation function by using the known values of the explanatory variables for the estimate [17].

4.4. Conclusion

Very good statistical results are obtained for both valuation functions. The explained variance of the purchase prices, in accordance with the model premises, is high with just under 89% [MDU] and 82% [CDO]. The difference between the actual purchase prices and the estimated hedonic prices does not exceed 80% of the forecast values for both MDU and CDO. Very good results were also achieved at the overall portfolio level with a deviation of 2.8% [MDU] and 2.7% [CDO]. In this example, the econometric models provide good to very good estimation results, which [inter alia] can be used for portfolio evaluations and/or plausibility checks of valuation results. The quality of the data is the decisive foundation for the development and estimation of the models. In addition to the evaluable transaction period, the number of available purchase prices and the collected characteristics with their differentiated recorded characteristic values are of particular importance. Furthermore, it is more advantageous if the data originate from a homogeneous source. However, this is not absolutely necessary and further information could close information gaps in the data stock. The sample must also be up-to-date and representative. Furthermore, the estimated models cannot be transferred unconditionally to other property markets.

5. Recommendations

It would make sense to expand the existing models by adding additional information with regard to vacancies, a contractually agreed rent deviating from the market rent and other typical factors affecting earnings. The use of additional socio-demographic or infrastructure variables can also refine the validity of the models and should be

the subject of future analyses. The application of such models in general also to other investment properties and thus to heterogeneous types of property can be assumed, but this requires empirical evidence first. Furthermore, the temporal consistency of hedonic models requires special attention and thus further analysis. Shifts in the property characteristics considered relevant by participants in the real estate market are likely, as is their implicit willingness to pay for precisely this property. This would possibly result in the need to re-specify the models.

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