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### Biographical Details (if applicable):

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Born 1981 in Heidelberg Philipp Deschermeier studied Economics at the University of Mannheim. Between 2007 and 2013 he worked as a Research Assistant at the Chair for Economics of Geography at the University of Mannheim. His PhD thesis covered the topics regional development and demographic change. Since 2013 he joined the Cologne Institute of Economics at the Research Unit for Real Estate Economics.

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Born 1975 in Leverkusen, studied Economics in Münster and Cologne. Between 2000 and 2005 Research Assistant at the Institute for Economic Policy at the University of Cologne, department Prof. Dr. J. Eeckhoff. Since 2005 at the Cologne Research Institute for Economic Research and since 2008 Head of the Research Unit for Real Estate Economics. Furthermore since 2011, honorary professor for Economics at Bonn-Rhein-Sieg University of Applied Sciences. Besides Michael Voigtländer is lecturer at the ebs and the irebs at the University of Wuppertal and at the Academy for German Cooperatives.

**Structured Abstract:**

This paper presents a hedonic price index for office and retail properties. A fundamental issue in constructing property price indexes is that properties are heterogeneous goods. As hedonic methods are able to adjust for the heterogeneous quality they gain more and more attention as a method for monitoring market development. The hedonic method got implemented for monitoring the development of the German housing market but not for the commercial property market. So the paper aims at closing this research gap. For constructing these indices two alternative methods are compared: the time dummy method and the hedonic imputation approach. The results are presented for the case of Berlin using supply data, which were provided by the German internet database "ImmobilienScout24". The outcome indicates that the hedonic imputation approach appears to be better in distinguishing quality and price effects. So the results based on it are more quality adjusted than the indices calculated with the time dummy method.

**Keywords:** hedonic regression, commercial property, Berlin, price index

**Article Classification:** JEL E30, R11, R33

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## 1. Introduction

Commercial properties play an essential role in economies. They are the most important real estate investment class for institutional investors, even more important than the housing market. On the other hand corporations and self-employed people consider commercial properties as input factors, for which especially the quality and costs matter. Despite the fact, that estate agents, consulting firms and banks publish market reports on a regular basis, the commercial property market lacks behind other investment markets in terms of transparency and data availability, as these reports only monitor very small fragments of the market.

Hedonic methods gain more and more attention in the literature. This is due to their ability of distinguishing between quality and price effects. As commercial properties are heterogeneous goods it is necessary to control for their different characteristics. And among the various methodological alternatives only hedonic methods can account for the diversity of properties. In Germany there are different price and rental indexes based on hedonic methods for the housing market but none for the commercial property market. This field remains a research gap.

On this account the paper aims at developing a hedonic rental price index for commercial properties using supply data for the case of Berlin. The index will be divided in 2 subcategories for office and retail. The data was provided by "ImmobilienScout24", a German internet platform. To find a suitable method for constructing an index, the time dummy method is compared to the hedonic imputation method. Our approach focuses on geospatial variables to improve the hedonic functions.

## 2. Price Indices based on hedonic regression models

The price index we are constructing needs to meet two demands: first it has to reflect the proper market development. Secondly it needs to be representative for the whole local market. The main issue of the different methodological approaches is that they can't adjust for changes in quality. Among a broad variety of methodological alternatives only price indexes based on hedonic methods meet these demands as they reflect the market development and can control for the heterogeneity of commercial properties.

Hedonic price indices are based on the hedonic hypothesis (Brachinger, 2002) that dates back to Waugh (1928). After receiving attention by the publications of Griliches (1961, 1971) the current methods got framed by Lancaster (1966) and Rosen (1974). The basic idea is that the real estate rental prices can be expressed by a set of its characteristics. This relationship between the price ( $P$ ) and the characteristics ( $x_i$  with  $i=1, \dots, N$ ) can be formalized by the functional form (Demary, 2009):

$$p = f(x_i)$$

There are different forms for the functional relationship. The simplest form is linear:

$$P = \beta_0 + \beta_1 X_1 + \dots + \beta_n X_n + u,$$

Where P is a vector with prices,  $X_1, \dots, X_n$  are vectors for the set of characteristics (of which some may be dummy variables) and  $\beta_0, \dots, \beta_n$  are vectors for the hedonic prices for the characteristics and u is a vector with random errors. In this regression model the price is the sum of its characteristics that are weighted by the price for each of the characteristics and observed with an error. As these prices are not observable they are shadow prices or so called hedonic prices. As this functional form corresponds to the linear regression model the hedonic prices can empirically be estimated for a set of observations for real estate prices along with data on their characteristics. This way the unobservable willingness to pay for certain characteristics can be quantified.

For constructing real estate price indices a semi logarithmic functional form is most common (Hill, 2011, 13):

$$\ln(P) = \beta_0 + \beta_1 X_1 + \dots + \beta_n X_n + u.$$

This paper compares two different regression approaches for hedonic modeling: the time dummy method and the hedonic imputation. The time dummy method is a pooled regression on all available observations. The model contains a set of dummy variables  $D_1, \dots, D_T$  correcting for the time periods  $t=1, \dots, T$  whose parameters  $\alpha_1, \dots, \alpha_T$  reflect the price changes relative to the base period ( $t=0$ ):

$$P = \beta_0 + \beta_1 X_1 + \dots + \beta_n X_n + \alpha_1 D_1 + \dots + \alpha_T D_T + u.$$

The hedonic imputation approach (Cominos et al., 2007) estimates separate models for each time period. These regression results are used along with the indices formulas from price statistics (for example Paasche, Laspeyres or Fisher) to compare the price development relative to the base period. These calculations require the same set of observations in the two periods compared: the base period and the current period. So the observations represent a “basket of commodities” like in the official consumer price index.

One issue with real estate is that transactions happen infrequently. Hence, the method aims at estimating the price of a property that is not offered in a certain period. The characteristics of this property are transported with the hedonic prices of the required period, resulting in a substitute price for the property. This imputation is done for the properties that are on the market in the current period resulting in imputed prices for the base period and vice versa. This results in the non-observable prices for the properties in both periods that are not on the market. So all properties have a real price (in the period they are on the market) and an imputed price (the period they aren't on the market). With these complete property baskets the standard price formulas from price statistics can be applied, resulting in an index for the market development (Hill and Scholz, 2013, 5).

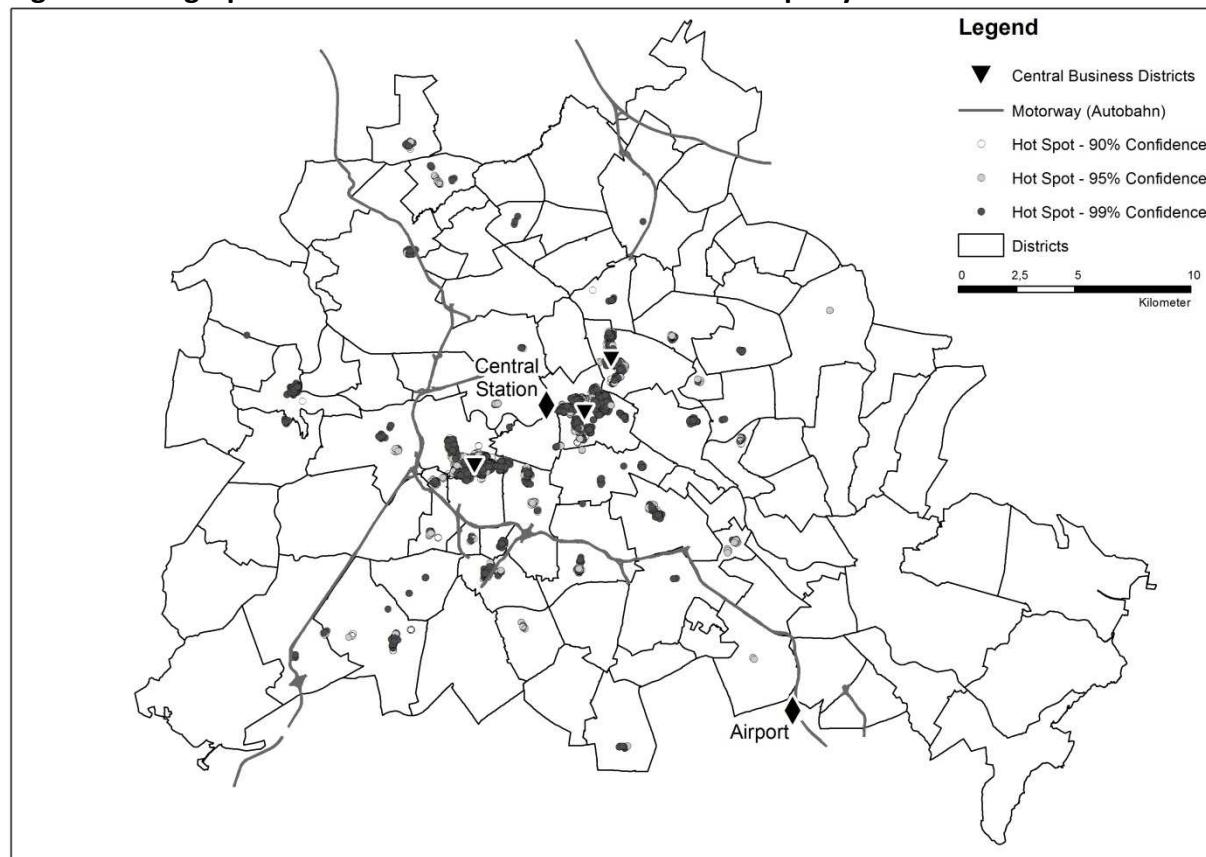
### 3. Case Study: Commercial property index for Berlin

ImmobilienScout24 is an internet platform for property advertisements. Besides housing properties the corporation's webpage features advertisements for commercial properties. The corporation is the founder of the “TransparenzOffensive” (homepage: [www.transparenzoffensive.net](http://www.transparenzoffensive.net)) which is an initiative for improving the transparency in the real estate markets. One of its actions for reaching this aim is to provide their collected data for scientific use.

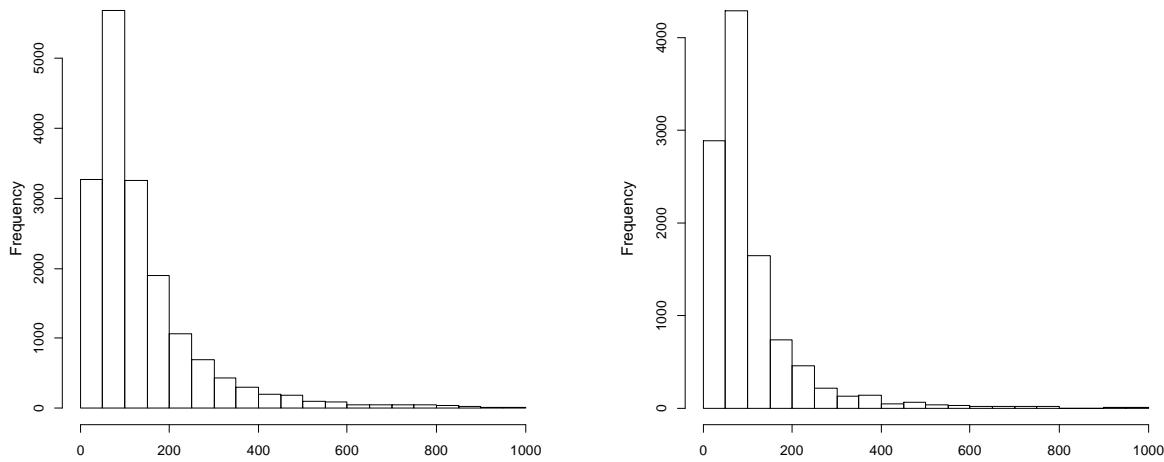
The present dataset was provided by Immobilienscout24 and features data on office as well as retail advertisements for Berlin for the years 2008 up to 2013. Beside the basic information on the price and the area of each property the advertisements contain plenty information on the geographic location, year of construction or the quality of the property. This information is used to frame the hedonic regression models. Table 1 and 2 provide some descriptive statistics on the datasets.

The dataset was extended by additional variables based on the geographical location of the advertisements. As all properties are geo referenced, we used the software ArcGIS to generate variables based on methods of the spatial econometrics (Anselin, 1988). A hot spot analysis by Getis and Ord (1992) was used to locate the central business districts (CBD) in Berlin. This is based on the idea of the model by Alonso (1964). For each advertisement the distance to the nearest central business district was generated as an exogenous variable for the hedonic regressions. Furthermore distance measures to the main station, the airport, the public transportation system and the nearest motorway were generated to model the geographical position of the properties. Figure 1 shows some of these variables for the case of Berlin.

**Figure 1: Geographical information on the Commercial Property Market in Berlin**

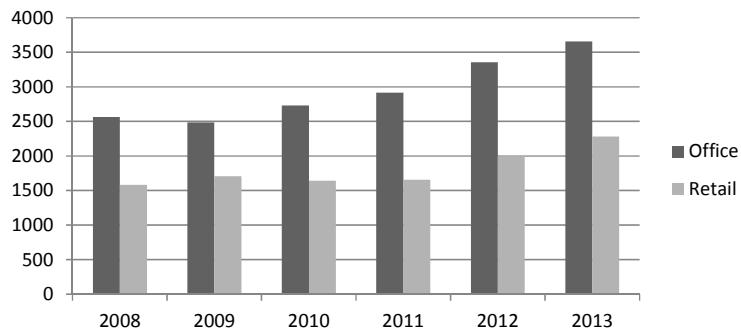


Source: Own calculation.

**Figure 2: Histograms for the rentable areas for office and retail advertisements in Berlin**

Source: Own calculation, data: ImmobilienScout24.

The hedonic regressions were done in R (version 3.0.2). The endogenous variable is the price per square meter. Figure 2 presents histograms for the rentable areas for office and retail advertisements in Berlin. The figure shows that the majority of the advertisements have rentable areas below 200 square meters. So the data provided by ImmobilienScout24 provide a more complete picture of the market than most market reports that usually focus on rentable areas above 200 square meters only.

**Figure 3: Number of observations for office and retail advertisements in Berlin (2008-2013)**

Source: Own calculation, data: ImmobilienScout24.

**Table 1: Econometric results for the location based variables.**

Regression Method	Time Dummy Method		Hedonic Imputation (2013)	
	Office	Retail	Office	Retail
Property type				
Log (dist. to Central Station)	-5.751e-02(***)	5.004e-02(***)	-6.617e-02(***)	2.070e-02
Log (dist. to Airport)	2.498e-02(*)	1.819e-01(***)	-2.357e-02(***)	1.269e-01(**)
Log (dist. to next motorway)	1.187e-02(***)	-3.583e-03	2.673e-02	3.386e-03
Log (dist. to next CBD)	-1.331e-01(***)	-1.392e-01(***)	-1.421e-01(***)	-1.584e-01(***)
Number of observations	17.699	10.862	3.656	2.281
Adjusted R <sup>2</sup>	0.3362	0.2177	0.3993	0.2924
significance codes: (***)<0.001; (**)<0.01; (*)<0.05				

Source: Own calculation, data: ImmobilienScout24.

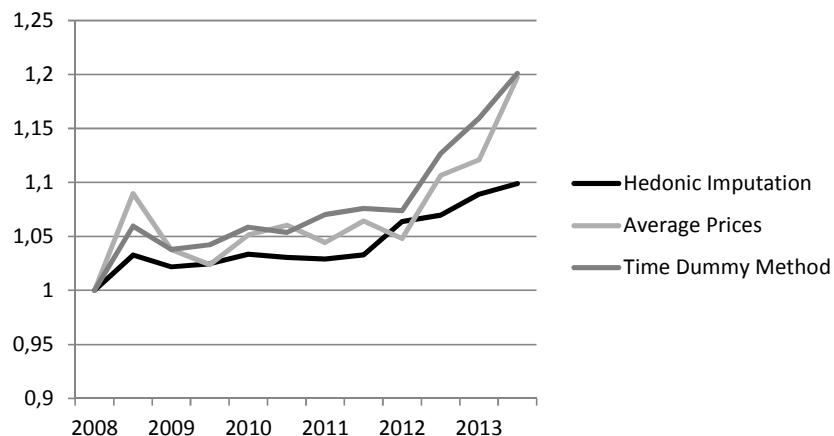
Table 1 provides some of the econometric results and focuses on the geographical variables due to the high amount of exogenous variables. The models done with the hedonic imputation approach are yearly

regressed using the adjacent period method to distinguish for half-years. The number of observations was steadily increased over time as figure 3 reflects and there are more observations available for office than for retail. Based on the results of the econometric models different indices were generated with the time dummy method and the hedonic imputation approach for office and retail commercial properties. These models contain dummy variables for making use of the observations that contain missing values. The results are shown in figure 4 and 5.

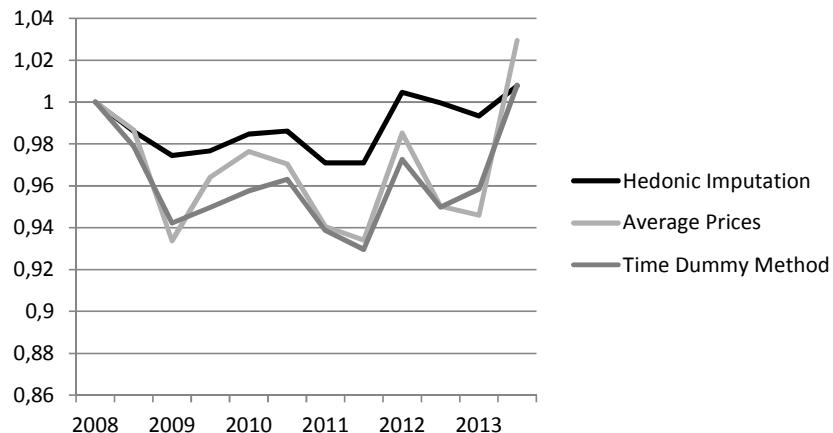
The results were monitored on a half-year basis. The price development of office rents (figure 4) runs at a constant level between the first half-year of 2008 and the second half-year of 2011. During that period the office employment was steadily increasing. 15.9 percent more people were employed in the office sector in 2013 compared to 2008. This is an over average increase compared to the level of Germany. On the other hand the rate of vacant office dropped significantly. In 2009 11.2 percent of the offices in Berlin were vacant, while this number dropped down to 7.0 percent in 2013. These two effects caused the price development to appear pretty stable until the second half-year 2011. The increasing demand for offices could be satisfied with vacant offices. After 2011 the increasing employment caused the prices to rise significantly, especially for high quality properties.

This development can be seen in all three indices in figure 4. The office rents monitored with the time dummy method and the average price method run on a much higher level than the level calculated with the hedonic imputation approach. This is especially true for the most recent periods. For the second half-year of 2013 the time dummy method reports an increase of 20 percent points in office rents while the hedonic imputation only reports +10 percent point. This illustrates the advantage of the hedonic imputation method as it is better capable of distinguishing between price and quality effects. The overall quality of the advertisements steadily increased over time. The average of the advertisements that were tagged “luxury” or “lofty style” increased from 6.2 percent in 2008 to 21.3 percent in 2013. Market development should therefore be done with the hedonic imputation approach as it reports a price index that is better quality adjusted than the results monitored with the time dummy method.

**Figure 4: Price Indices for the office market in Berlin (2008-2013)**



Source: Own calculation, data: ImmobilienScout24.

**Figure 5: Price Indices for the retail market in Berlin (2008-2013)**

Source: Own calculation, data: ImmobilienScout24.

The price development for retail rents runs less volatile. All three indices show much weaker peaks over time. But again the average price method and the time dummy method report larger peaks than the results calculated with the hedonic imputation. Between 2008 and the end of 2013 the price index based on the hedonic imputation varies by 4 percent points. After a small decline after 2008 the price level in 2013 increased back to its initial level.

## 4. Conclusion

Monitoring the development of the commercial property market is important as this market is the most important real estate investment class for institutional investors. But unlike the housing market the market for commercial property is far away from being transparent due to missing data sources. Existing market reports focus only on small segments and fragments.

On this behalf this paper aims at constructing an index that is representative for the market and also quality adjusted. Hedonic methods were therefore used for the calculations. The time dummy method and the hedonic imputation approach were compared. The results indicate that hedonic regressions are a powerful approach in constructing quality adjusted price indices. Especially the hedonic imputation method is capable of distinguishing quality from price effects.

For the office market stable prices were monitored until the end of 2011. The increasing office employment was compensated by plenty vacant offices in Berlin. With the beginning of 2012 only few high quality offices were available causing prices to rise. The market for retail properties is less volatile. After a minor decline the prices stabilized slightly above the initial level.

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**Running Heads:**