A transactions-based commercial property price index for Portugal

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Abstract

The last decade has witnessed a renewed interest in the production of real estate price indicators. Despite of the progress in the production of residential property price indexes, commercial property price indexes (CPPI) have remained a less researched topic. This paper presents the work of *Instituto Nacional de Estatística* and *Banco de Portugal* to develop the official CPPI for Portugal. It is the first time that the evolution of national commercial real estate prices has been traced down using a dataset that covers the population of transactions and that provides information on property transaction prices and their characteristics. This paper presents the results of a quarterly CPPI from the beginning of 2009 to the first quarter of 2016 using the hedonic method, which is also applied in the production of the House Price Index (HPI). Although with a similar trend as the HPI, the new indicator reveals that the prices of commercial properties have decreased more than the prices of residential properties in 2012 and 2013, a period during which real estate markets were depressed. The work presented is not only of interest to the price index compilers involved in the development of similar indexes but also to researchers and all those interested in the evolution of commercial property markets.

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1. Introduction

The latest global financial crisis has demonstrated how real estate markets can influence the economy and, at the same time, disclosed the need for more and better data for monitoring purposes. A clear indication of this need was provided in a 2009 report of the International Monetary Fund and the Financial Stability Board, which included as one of their key recommendations for the enhancement of worldwide financial stability the production and dissemination of more comparable data on real estate prices (IMF and FSB, 2009). Real estate indicators, particularly indexes measuring the evolution of prices, are of the utmost importance since they can be used for monitoring the risks of the financial sector, designing appropriate macroprudential and monetary policies and as an input for National Accounts or other official statistics. An excellent summary of the possible uses and target indicators for real estate price indexes is available in Diewert (2009).

While some notable progress has been achieved for residential property price indexes (see, *inter alia*, Eurostat, 2013), CPPIs have remained a less explored topic. Despite the relevance of some recent initiatives, such as the development of a draft technical handbook in this area (Eurostat, 2015) or the technical reports on real estate (ESRB, 2015), there is no harmonized methodology for constructing a CPPI. Overall, it can be said that there is a lack of official and comparable statistics on the commercial property market, with the majority of the data describing it being produced by the private sector. The situation is similar in the case of Portugal, where an official residential price index is produced since July 2014 (INE, 2014) and, despite the existence of private sector price indexes based on list prices and appraisal values, no official transactions-based price statistics covering the entire commercial property market exist. In order to fill this data gap, the *Instituto Nacional de Estatística* and *Banco de Portugal* have combined efforts and created a joint project to develop a CPPI. The aim of this paper is to present the outcome of this project. It provides the results of a new quarterly CPPI for Portugal for the period ranging from the first quarter of 2009 to the first quarter of 2016. The new price index is based on a dataset combining information about the characteristics of the stock of commercial properties, as registered in the municipal property tax (IMI)[1], and on transaction prices, as registered in the municipal transfer tax (IMT)[2].

The results presented in this paper confirm the possibility of compiling a national transactions-based constant quality hedonic price index, which was disaggregated into retail, services and industrial properties. With this new indicator, it is possible to satisfy an important data need and to provide a more complete picture of the Portuguese real estate market. As such, the work presented in this paper is not only important to those interested in the development of similar indexes but also to researchers and to all those interested in the evolution of commercial property markets over the last years.

This paper is organized as follows. Section two reviews the existing theoretical and empirical practices surrounding the compilation of CPPIs. Section three presents the empirical model

[1] In Portugal, this tax is designated as *Imposto Municipal sobre Imóveis* or as IMI. For convenience, its abridged name IMI will be used in the text whenever the tax needs to be identified.

[2] Transfer tax is designated as *Imposto Municipal sobre a Transmissão Onerosa de Imóveis* or simply as IMT. Following the same approach that was used for property tax, the Portuguese abbreviated expression will be used throughout the text to designate it.

that was used as the basis to produce the CPPI. Section four describes the dataset supporting the compilation of the new indicator. Section five presents the results of the CPPI for the period under analysis. Finally, the last section provides the conclusions of this paper.

2. Theory and practice of commercial property price indexes

2.1. Conceptual Scope

Given the inexistence of a clear-cut separation between commercial and non-commercial properties, certain type of transactions appear as grey areas and as potential candidates to be ruled out from the scope of a CPPI. As a starting point, it can be said that commercial properties comprise all combinations of land and building structures that generate profit or income from capital gains or rents (ESRB, 2015). According to this definition, commercial properties exclude owner-occupied housing, as well as properties under development and property owned by companies and used as part of their capital stock (i.e., "corporate real estate"). The inclusion of buy-to-let properties is controversial and the ESRB (2015) recommends its exclusion from the scope of commercial properties (at least as long as a consensual definition on its inclusion or exclusion does not exist).

An interrelated conceptual issue has to do with the definition of the types of commercial properties. Although there is no complete agreement on this issue, it can be said that commercial units are often divided into offices, retail and industrial properties and, less frequently, grouped into an additional rental residential category (Eurostat, 2015). In relation to the importance of this last property type, there is some anecdotal evidence suggesting that the number of residential properties that is leased or bought in Portugal with a commercial purpose in mind is much smaller than the number of properties transacted for own-occupancy or purchased for retail and office purposes. Furthermore, the administrative tax data that is used to compile the HPI in Portugal does not identify residential units that are bought with a commercial purpose in mind. The data source used in this study categorizes real estate properties transactions as residential or commercial, with this last category encompassing retail, services and industrial uses. In light of this categorization, the inclusion of buy-to-let properties in the CPPI, even if possible, would result in a partial overlap with the HPI. For all these reasons, it was chosen to exclude residential properties from the scope of the Portuguese CPPI. In summary, the decision on what to include under the realm of the CPPI for Portugal is based on the idea of income-generating property (ESRB, 2015) and the categorization of commercial properties is done according to their end use, as stated in administrative tax data sources.

Another conceptual issue has to do with the definition of price. As a guiding principle, a CPPI should be based on transaction prices. However, due to the lack of information on transactions, index compilers have to sometimes use a proxy variable such as appraisals. An appraisals-based index makes use of appraisal information on property prices, while transactions-based indexes make use of actual transaction prices. Appraisals-based indexes (and hybrid variants, which combine appraisals and transaction prices) present well-known caveats, which include price change smoothing, inability to promptly identify turning points and vulnerability to client influence (Devaney and Diaz, 2011; Geltner et. al., 2003). When available, the use of transaction price data provides a more accurate and objective depiction of price evolution with a more precise estimation of the timing and magnitude of price changes. The database that was used to compile the CPPI has information on transaction prices.

2.2. Literature Review

The compilation of CPPIs is more challenging than similar residential property price indexes due to two reasons. The first reason relates to the higher heterogeneity of commercial properties and to the type of asset in question. Prices of commercial properties are expected to be more volatile than those found in the residential market, since the former properties are more reactive to business cycles and macroeconomic conditions than the latter (Davis and Zhu, 2009). Furthermore, the commercial market is much more segmented and heterogeneous than its residential market counterpart. The second reason is the small number of transactions in commercial property markets (Silver and Graf, 2014). In fact, commercial transactions may be sporadic, a situation that may introduce noise in the estimation of period to period price changes. As a consequence of these reasons, the literature points out that transactions-based CPPIs are less precise than residential property price indexes (see, *inter alia*, Diewert et al., 2016: 17).

Ahmad et al. (2014) and Shimizu and Karato (2015) provide reviews of the methods that can be used for the compilation of CPPIs. The handbook on CPPIs (Eurostat, 2015), which is still in its development phase, will also provide an account of the approaches that can be used in this area. Finally, a comprehensive and recent review of the different types of hedonic regression methods that can be used in the compilation of constant-quality property price changes is available in Silver (2016). There are a few insights that can be drawn from these surveys. The first one is that the literature providing empirical evidence on this indicator is not abundant. This reflects the aforementioned difficulties associated to the compilation of CPPIs, specifically the scarcity of data and of the lack of consensus on key concepts and definitions. The US and Japanese markets account for most of the officially published CPPIs[3]. To the best of our knowledge, Statistics Denmark is the only statistical office in Europe producing an official CPPI (Statistics Denmark, n.d.). This index is produced quarterly and is based on the Sales Price Appraisals Ratio (SPAR) method (Bourassa et al., 2006). In Germany, two private entities, the BulwienGesa AG and the Association of German Pfandbrief Banks, have recently started publishing CPPIs. While the former uses a method of typical cases to produce a valuation-based annual index for 125 German cities, the latter is based on mortgage collaterals data and the hedonic regression method to compute a transactions-based quarterly index for office buildings only. Zollino (2013) provides experimental results for Italy, including semi-annual indicators for office and retail commercial assets and a quarterly national indicator.

Secondly, these surveys evaluate and categorize methods of compilation into transactions-based, appraisals-based and hybrid compilation methods. However, contrary to housing property price indexes (Eurostat, 2013), where some preference is given to the hedonic approach, in the commercial segment, there is no clearly preferred method. Shimizu and

[3] See, for instance, The National Council of Real Estate Investment Fiduciaries Transactions Based Index and the Investment Property Databank Index for the USA, and the Ministry of Land, Infrastructure, Transport and Tourism's CPPI for Japan (Eurostat, 2015).

Karato (2015) point out that, in order to deal with property heterogeneity, quality-adjustment methods such as hedonic or repeat-sales (Bayley et. al, 1963) methods are preferred. Hybrid indexes, such as those derived using the SPAR approach, can also be used. However, this type of methods requires the existence of a complete and reliable appraisals system and has difficulties taking into account new buildings and quality change due to depreciation and renovations. On the other hand, as Clapp and Giaccotto (1999) point out, repeat-sales indexes are prone to large and systematic revisions and, as they make use of only repeated sales, are subject to sample bias. This seems to be the situation with the present study, with repeat-sales accounting for only 35.5% of total transactions of the data available for the compilation of the CPPI for Portugal.

Hedonic methods on the other hand, make use of all available information and control for quality differences by formulating the price of a dwelling as a function of its characteristics (Silver, 2016; Hill, 2013). In addition, in presence of the right variables, the use of hedonic models in price index compilation can also provide a framework in which depreciation and renovations can be accommodated. Some of the drawbacks that are associated with the use of hedonics include misspecification, omitted variable bias, selection bias and dealing with sparse data. If the number of transactions is low and the number of characteristics in the hedonic price functions is large, there may be a problem in the estimation of the model. The dataset used in our work covers the whole population and avoids most of these shortcomings. As sales registration is mandatory by law, all transactions are covered. Moreover, the data includes a wide range of price-determining characteristics and purchase prices are recorded in time to be considered representative of the moment of transaction. For commercial real estate (CRE), first attempts of using hedonic methods to model price changes remote to Colwell et al. (1998) for office sales in Chicago. More recent references for the application of this method include Devaney and Diaz (2011) and Bokhari and Geltner (2012).

Finally, it is worth mentioning that several working groups have been created under the aegis of international technical forums to stimulate the compilation and dissemination of commercial property price statistics. In particular, the G-20 Data Gaps Initiative of the International Monetary Fund and the Intersecretariat Working Group on Pricing Statistics of the International Labour Organization have encouraged the debate over conceptual, methodological and practical issues. In addition, the European System of Central Banks aims to produce a quarterly quality constant euro area CPPI as well as indexes by country. However, this work is still at a very experimental stage and makes use of appraisal based data provided by non-government entities, as well as interpolations of annual to quarterly data (ECB, 2014).

3. Commercial Property Price Index Model

In order to compile a transactions-based constant quality national CPPI, a compilation strategy combining stratification and the hedonic price model was chosen. Following end use definitions of each transacted property available in the administrative tax data source, three strata - Wholesale and Retail Commerce; Services; and Industrial and Warehouses[4] - were considered. It should be noted that, it was not possible to provide the price evolution for offices separately. In principle, some transactions of offices could be identified through a variable that indicates whether a property is located in an office building or not. However, the number of transactions located inside an office building is not large enough to provide the basis for a reliable index. Of all of the transactions classified in the raw data as Services, 3,527 transactions are signaled as being located inside an office building (i.e., an average of 122 transactions per quarter). In addition, this index would not capture all office transactions since not all of them are located inside an office building. For these reasons, office transactions and their price evolution are modeled within the Services sub-index.

The application of the aforementioned strategy implies that a hedonic price model (and sub-index) is specified for the retail, services and industrial commercial property markets. The sub-indexes are compiled using the hedonic regression time dummy approach, in which two adjacent quarters of data are used to estimate the quarterly price change (Diewert, 2005). This technique assumes that the implicit prices of the characteristics are constant over every two quarters, which is a more flexible assumption than what is implied in an all-periods pooled time dummy approach (i.e., assuming them as constant throughout time; Triplett, 2006; Silver, 2016). This approach can also be seen as a particular case of the overlapping-period or rolling window hedonic model proposed by Shimizu et al. (2010)[5].

The adjacent time dummy regression, which is applied in the production of the Portuguese HPI (INE, 2014), can be described for all pairs of adjacent quarters *q = (Q-1,Q)*, dwelling transactions *i = 1, …, N* and dwelling characteristics *k = 1, …, K,* by the following population hedonic function, calculated for each stratum:

$$\log(P_{i,q}) = \alpha + \sum_{k=1}^{K} \beta_k X_{i,k,q} + \theta D_{i,q} + \epsilon_{i,q} \qquad (1)$$

where $log(P_{i,q})$ is the logarithm of the price level of the i^th^ dwelling transaction in quarter *q*, $X_{i,k,q}$ is the value of the k^{th} characteristic of the i^{th} transacted dwelling in quarter *q*, $D_{i,q}$ is a temporal indicator defined as

$$D_{i,q} = \begin{cases} 1, if\ q = Q \\ 0, otherwise \end{cases} \qquad (2)$$

and $\epsilon_{i,q}$ is the error term, with an expected value of zero, given any values of the explanatory variables: $E\left(\epsilon_{i,q} | X_{i,1,q}, \dots, X_{i,K,q}, D_{i,q}\right) = 0$. Equation (1) is assumed to be linear in the parameters and, in addition, not to be affected by perfect collinearity and estimated using a representative sample of the population of commercial transactions. Under these assumptions, the Ordinary Least Squares (OLS) estimators $\hat{\beta}$ and $\hat{\theta}$ are unbiased estimators of

[4] Hereafter simply referred to as retail, services and industrial.

[5] A comparison of the adjacent, rolling window and pooled time dummy hedonic CPPIs is provided in Section 5.1.

β and θ (see, *inter alia*, Wooldridge, 2003). The θ and the other parameters in Equation 1 are fixed and may change each time a pair of adjacent quarters is used in the estimation process.

After estimating Equation (1) by OLS, the elementary index reflecting a price change between any two quarters *Q-1* and *Q* for stratum *j* ($I^j_{Q-1,Q}$, j=1,2,3) is approximated by the formula [6]:

$$I^j_{Q-1,Q} = \exp(\hat{\theta}) \qquad (3)$$

For the computation of the price variation between two non-adjacent pairs of quarters, a chain formula is used. Thus, for the compilation of the price change between quarter *Q-N, N≠1*, and *Q*, the following formula is applied:

$$I^j_{Q-N,Q} = \prod_{i=0}^{N} \mathrm{I^j}_{\mathrm{Q-1-i,Q-i}} \qquad (4)$$

For calculating the overall CPPI, weights for the retail, services and industrial sub-indexes need to be compiled. In order to reflect up-to-date expenditure patterns, the weights, which are used in index numbers of year *Y*, are compiled using the sales prices of all N transactions carried out in year *Y-1* ($p_{i,Y-1}$)[7]. Following a procedure that is applied in the HPI and other price indexes, the weighting structure found after this step is price updated to the last quarter of year *Y-1*, the period in which the different annual weight schemes are linked together into a single index number time series. The following formula illustrates these calculations for the weight of stratum j used in year Y (v^j_Y):

$$v^j_Y = \frac{\sum_{i=1}^{N_j} p^j_{i,Y-1}}{\sum_{i=1}^{N} p_{i,Y-1}} * u^j{}_{Y-1} \qquad (5)$$

Where $u^j{}_{Y-1}$ is a price update factor defined as follows:

$$u^j_{Y-1} = \frac{I^j{}_{Q-2,Q-1}}{\frac{1}{4}\sum_{i=1}^{4} I^j{}_{Q-1-i;Q-i}} \qquad (6)$$

Final weights ($w^j{}_Y$) are obtained by simply normalizing (5) in the following way:

$$w^j{}_Y = \frac{v^j_Y}{\sum_{j=1}^{3} v^j_Y} \qquad (7)$$

The final index is computed as:

$$I^Y_{Q-1,Q} = \sum_{j=1}^{3} w^j_Y (I^j_{Q-1,Q}) \qquad (8)$$

Using this procedure, the CPPI can be best described as a Laspeyres-type index, with annual weighting and chaining. For the compilation of the price change between non-adjacent quarters, the chaining principle as shown in (4) is applied to (8).

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[6] Kennedy (1981) notes that this type of formulation produces biased estimates and proposes an alternative estimator. However, for large samples (as it is the present situation), the results of Kennedy's (1981) correction are almost negligible and were not used in this work.

[7] The only exception to this rule is given by the indexes compiled for 2009, which use information from that same year. This stems from the fact that there is no information available prior to 2009. For the index numbers of year 2009, the weights are not price updated.

4. Data

4.1. Sources

The IMT and IMI tax data used in this paper is provided on a monthly basis by the Portuguese Customs and Tax Authority to *Instituto Nacional de Estatística*. The IMT provides information on all transaction prices. This data source covers the population of transactions since a proof of payment of the property transference tax has to be shown by the buyer before a sale effectively takes place. The IMI provides information on property characteristics that are collected by the tax authorities for valuation purposes. In order to have a dataset with prices and characteristics of sold commercial properties, the two data sources had to be merged using each property's cadastral register identification number as the linking variable of IMT and IMI information.

The match of the IMT and IMI data is done on a monthly basis. On average, nearly 90% of all IMT transactions of commercial properties are paired with IMI information. There are three main reasons explaining the existence of unmatched transactions. The first one has to do with the fact that, although covering almost entirely the stock of commercial properties, the IMI data made available does not cover the appraisals carried out from December 2003 (i.e., when the tax was first introduced) to December 2004. As a result of this, there may exist commercial properties left unmatched because the IMI information on its characteristics was collected during that period. The second reason stems from the nature of the IMI, which generates information that can be corrected or contested by who pays IMI tax. If there is no agreement on an appraised value, it is possible to ask for a revaluation and the transaction may stay with no paired IMI information until the appraisal is considered final. The IMI information can also be contested for other reasons, such as when appraisals are based on erroneous information (e.g., erroneous areas). Finally, some transactions may be left unmatched due to the existence of errors in property identification numbers.

For the compilation of the CPPI, only transactions of retail, services and industrial dwellings were considered. Properties such as individual garages, parking facilities, land plots for future construction and residential dwellings were dismissed. In order to restrict, as far as possible, the scope of the analysis to market transactions, "barter-like" deals (*Permutas*) and zero transaction values were excluded. Transactions of the same dwelling occurring in the same day or in successive days, as well as cluster sales (single transactions encompassing multiple dwellings), were equally dropped. Finally, transactions in which any type of sales information was missing and were classifications of property use differed in IMT and IMI registers were also excluded from the analysis. The application of these rules eliminated around 8% of the data that was initially merged.

To implement the hedonic methods successfully it is essential that the variables expressing properties' characteristics are of good quality. One way to assess the quality of characteristics is to check whether these are included in the computation of the IMI tax. Variables included in the computation of this tax include, among other, age, location, and quality and comfort characteristics. In this sense, since these variables receive more attention from taxpayers, they are expected to satisfy higher standards of quality than others (and are, hence, given priority in a possible inclusion in the hedonic price model). Other variables, such as micro-level and coded location variables (postal code dummies) are also of good quality. After the application of the matching and cleaning procedures, the dataset available for analysis had 77,333 transactions covering the 2009Q1 to 2016Q1 period (an average of 2,667 observations per quarter).

4.2. Data analysis

As a first quality check of our database, the number of transactions registered in the IMT records was compared to the number of notarial purchase and sale contracts of urban dwelling transactions, which are compiled by a Directorate-General of the Portuguese Ministry of Justice (Figure 1.1, Appendix 1). When the two sources were confronted, it was possible to see that number of commercial and residential property transactions represented 95% of the total number of purchase and sales contracts. This is an expected outcome as purchase and sale contracts of urban properties include transactions of properties that were filtered out from original raw IMT records (e.g., individual garages). The size of the commercial property market was also compared to its residential counterpart. It is widely known that commercial property markets are less liquid than their residential counterpart. In this sense, it is not surprising to see fewer commercial transactions, representing an average of 11% of total residential sales.

Regarding the distribution of transactions across time (Figure 1.2, Appendix 1), it is possible to see a decreasing trend in the number of transactions from 2009 to 2013, followed by a slight increase from 2014 onwards. This is coherent with *a priory* expectations on the behavior of the real estate market during this period, which was markedly influenced by harsh credit constrains and a depression from 2011 to 2013 [8]. Moreover, the existence of year-end seasonality is clear for all strata, with transactions peaking over the fourth quarter of each year, and with troughs in the third quarter of each year. Seasonality in real estate activity is a well-known phenomenon, with could possibly be justified by the reaction to the fiscal calendar or explained by accounting/balance sheet purposes. As for the distribution of sales across strata, most of the transactions are categorized as Retail, representing 52% of the available data. The transactions of dwellings identified as Services, on the other hand, account for 26% of the database. Purchases of Industrial properties represent 22% of the data available for the compilation of the index. The table below presents the mean, median and standard deviation for three key variables, the transaction value, gross floor area and year of the commercial property at the time of transaction.

Table 1. Descriptive statistics for transaction price and gross floor area

	Retail			*Services*			*Industrial*			*All data*		
	Price	*Floor area*	*Age*	*Price*	*Floor area*	*Age*	*Price*	*Floor area*	*Age*	*Price*	*Floor area*	*Age*
Mean	120,179	117	20	296,592	229	20	220,991	742	27	187,922	285	21
Median	60,000	77	13	83,800	79	13	80,000	340	18	68,000	89	14
Stdev	540,145	334	23	1,373,707	943	24	964,620	1,845	28	921,587	1,051	24
n	40,269			19,871			17,193			77,333		

Note: Price in €, Gross Floor Area in square meters. Number of observations is denoted as n.

[8] Following a period of increasing difficulties, Portugal asked for financial assistance from the European Union and the International Monetary Fund in May 2011. The program of financial assistance, which was agreed by these institutions and the Portuguese government ended in June 2014.

The descriptive statistics show expected results. The median values of the three variables are always lower than their mean values, a feature that is typical of positively skewed distributions. Moreover, the highest floor area average is found for industrial properties (742 square meters) and the lowest average price is provided by the transactions of retail properties (120 thousand euros). Finally, services (which include offices) and industrial data show a higher dispersion around mean values, which reflects the existence of more heterogeneity in these types of properties.

5. Results

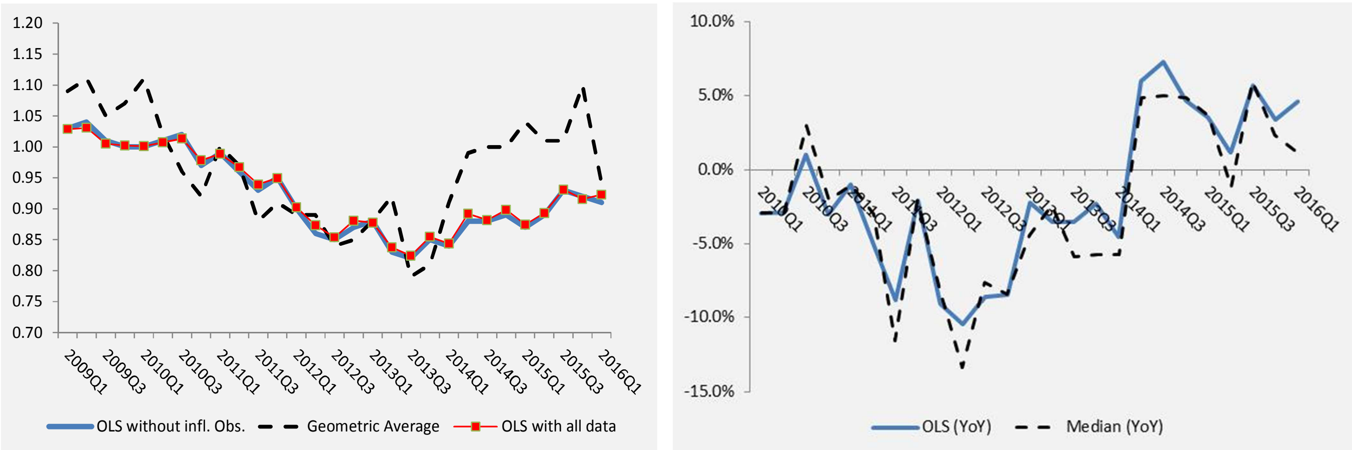
5.1. Hedonic Price Model Results

The development of a CPPI based on the hedonic model presented in section 3 involved the investigation of four key issues. The first one revolved around the concrete definition of the price models. As theory sheds little light on the selection of the appropriate functional form of the hedonic model (see, *inter alia*, Butler, 1982), the definition of the commercial property price functions were essentially guided by, on the one hand, the need to guaranteed the inclusion of key characteristics in the final model specifications and, on the other, the empirical analysis of the results. In practice, this involved the categorization of available variables into groups of price-determining characteristics (e.g., location, age and area variables) and the adoption of a trial an error process in which statistical tests provided assistance in defining the hedonic functions. A summary of regression outputs of chosen hedonic models is available in Appendix 3 and the complete list of used explanatory variables is in Appendix 4 (the model's dependent variable is the natural logarithm of transaction price). Overall, regression outputs provide good indications as to the statistical properties of the chosen models. The observed signs of the estimated coefficients generally coincide with expectations and many of the estimated coefficients were reasonably stable over the 28 regressions in which the adjacent time dummy was run. Finally, the adjusted R^2 was found to be lower for Retail, but still acceptable for pooled cross sectional regression analysis (see last table of Appendix 3).

The second issue focused on the adequacy of the OLS estimator, which was investigated in light of the assumptions described in Section 3. Some of these assumptions were already met by the design of the estimation exercise. For instance, as the data source covers the population of commercial property transactions, problems stemming from the use of unrepresentative samples were not a reason of particular concern. However, the existence of heteroskedasticity, which does not affect the unbiasedness of coefficient estimates, but distorts the variance of OLS estimators (and invalidates the use of usual test statistics), had to be tested empirically. As the hypothesis of homoscedasticity was massively rejected, all joint and individual tests were conducted using robust procedures (including heteroskedasticity tests). In particular, a Ramsey (1969) type test, based on a procedure that uses Lagrange-Multiplier (LM) statistics developed by Wooldridge (1991), was applied to test the general suitableness of linear in the parameters specifications and to generate evidence on parameter instability (see below). The number of variables included in available database, which is much larger than most studies in this area, was also explored to minimize the possible harm caused by omitted variables. For instance, the correlations between regression residuals and the variables that were not included in the regression were analyzed. If the correlation was moderate (around 20%), regressions were rerun with that covariate included in the specification. Moreover, the Variance Inflation Factor was computed to identify cases in which multicollinearity was severe.

The third issue investigated the degree to which the OLS estimator was influenced by individual data points. When using the time dummy, some commercial property transactions, whose characteristics differ a lot from the average transaction and whose prices are not well predicted by the regression, may be attached a big weight and bias the results (see, on this, Silver, 2016). In order to investigate the robustness of the OLS estimator, the hedonic regressions were run a first time with all observations and a second time without those data that were identified as influential (as measured by Cook's distance) and to have large residuals (as measured by studentized residuals; their absolute value higher than 3). The elimination of influential observations with large residuals represented a drop in the number of available transactions of around 1%. As a further benchmark to the results obtained from this two-step estimation procedure, a quality unadjusted CPPI, which was compiled using the geometric averages of all transaction prices, and a CPPI extracted from the median quantile estimator, which is deemed to be more robust to outliers, were also computed using all data. Figure 1 presents the results for these indexes.

Figure 1. OLS, geometric and median CPPIs



Looking at the left panel, it is evident, as expected, that the application of the stratification and hedonic method reduces the volatility that is seen in the unadjusted Jevons price index. It is also possible to see that the indexes stemming from the two regressions (with and without influential observations) are not much different. Moreover, it is possible to see from the right panel of Figure 1 that, overall, the OLS (mean) figures without influential and large residual observations are not markedly different from the median estimates. In light of these results, it was chosen to base the estimation on the two-step estimation process in which influential and outlying observations are ruled out from final calculations.

The last issue involved a comparison of alternative time dummy methods in which the length of the time window (i.e., the number of quarters) included in the regression model differed. In this context, it was found useful to generate evidence on the stability of the regression coefficients across time. This could be done through the Reset type test: while the reasoning of pooling all the periods into one regression in based on the idea of stable parameters across time, the adjacent time dummy method only assumes this restriction for two consecutive periods. Thus, if the results of the Reset type test reject the pooled time dummy specification and do not reject the adjacent version, then this could indicate parameter instability and, as such, help defining the length of the time window to be included in the regression model. The next Table provides the results for a selection of Reset type tests that were carried out using the pooled and adjacent year regressions.

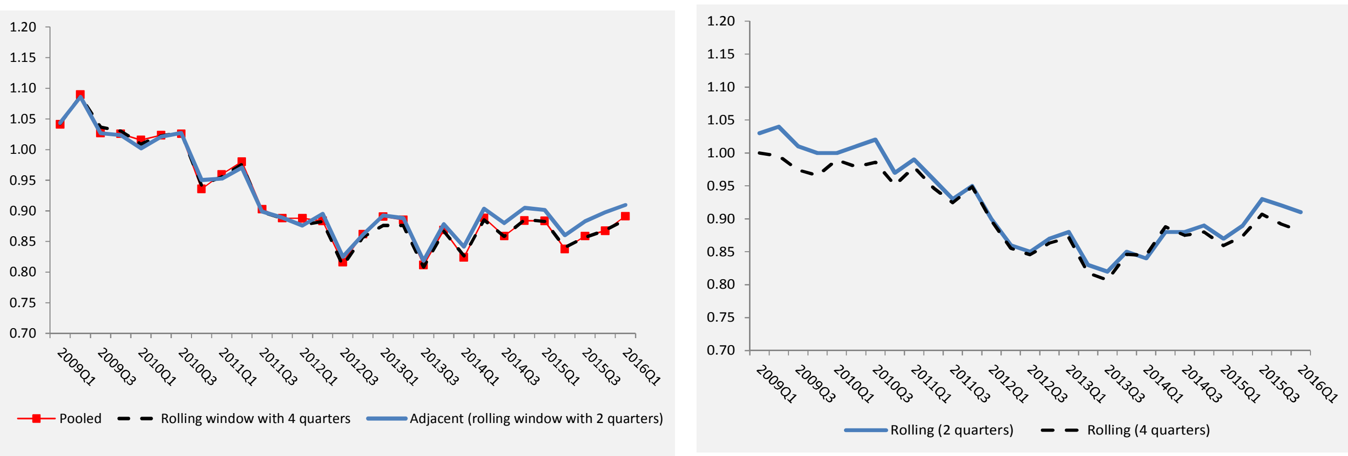
Table 2. Reset type specification test results for different types of time dummy models

	Pooled 2009-2015 regression	*Time dummy regression method with two adjacent years*					
		2009-2010	*2010-2011*	*2011-2012*	*2012-2013*	*2013-2014*	*2015-2015*
Retail	1.61	0.0001	0.04	0.39	1.79	1.94	5.87
	(0.205)	*(0.994)*	*(0.836)*	*(0.532)*	*(0.182)*	*(0.164)*	*(0.015)*
Services	0,72	0.36	0.03	11.43	0.68	6.79	0.01
	(0.395)	*(0.548)*	*(0.865)*	*(0.001)*	*(0.409)*	*(0.009)*	*(0.926)*
Industrial	1.92	0.61	0.73	1.72	0.06	0.10	0.76
	(0.166)	*(0.433)*	*(0.392)*	*(0.189)*	*(0.804)*	*(0.752)*	*(0.385)*

Note: The null hypothesis of the test is the correct specification of the model. The p-values are shown between brackets and below LM test statistics.

The pooled and the great majority of the models using adjacent years pass the Reset test at usual significance levels. These results support the idea that parameters are reasonable stable across time and that the time dummy model can be used in the compilation of the Portuguese CPPI. However, the pooled time window was not considered an option for the compilation of this indicator since it involves systematic revisions. In order to decide the time length to use, it was decided to compare price indexes using different time windows. The left panel of the next Figure shows the index numbers for Retail when the pooled, rolling window (4 quarters) and adjacent (2 quarters) time dummy models were used. The right panel of the same Figure provides the indexes for the overall CPPI for each one of the time windows considered.

Figure 2. Pooled and rolling window RPPIs for the retail and for all commercial properties

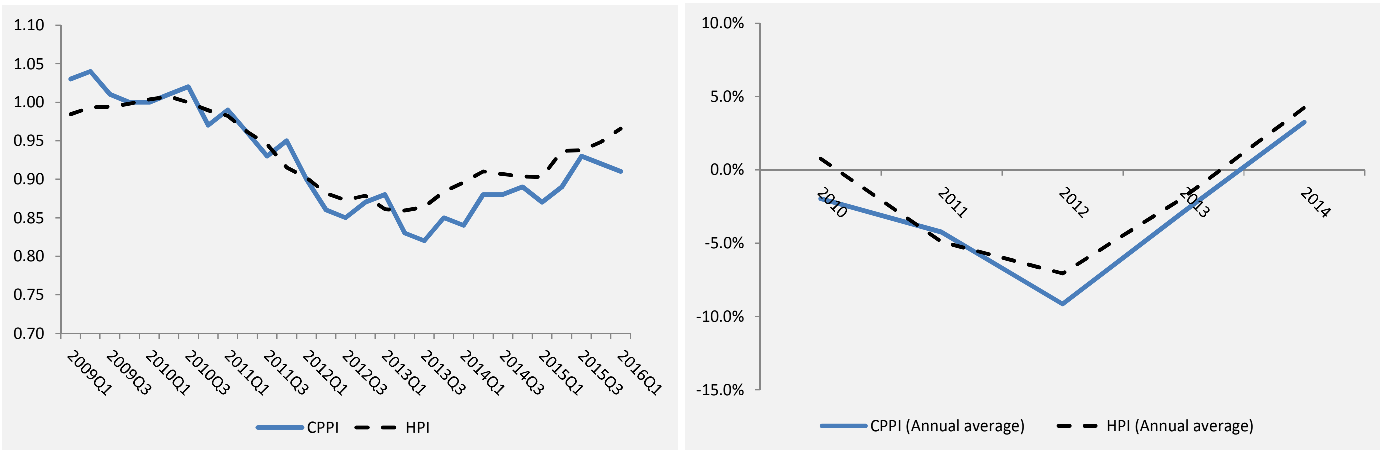


As Figure 2 highlights, the results obtained for the (all-periods) pooled time dummy and for the rolling window with 4 quarters did not provide any striking differences from the use of a rolling window with two adjacent quarters. This is even more evident when the indexes of the three strata are aggregated into a single index (right panel of Figure 2). In light of these results, and since the adjacent time dummy was already being used in the production of the HPI, it was chosen to use a rolling base of two quarters of data to produce the CPPI.

5.2. Evolution of commercial property prices since 2009

The next Figure compares the estimated CPPI to the HPI. These indexes are available in Appendix 2. On the left panel it is possible to see that the commercial and residential market have followed similar trends. In particular, it is possible to see that both commercial and residential property prices decreased until the middle of 2013 and recovered from that period onwards.

Figure 3. Comparison between the HPI and CPPI



As expected, the CPPI presents more volatility than the HPI. This may be due to the reduced number of transactions in commercial real estate, or even by the own nature of the commercial market segment. Nonetheless, as the left panel of Figure 3 shows, the trends and turning points shown by the two indicators are similar.

As can be seen from the right panel of Figure 3, prices of commercial properties have fallen more than the prices of residential properties, especially in 2012 and 2013, years in which the real estate market was depressed. This is even more evident if year on year figures are analyzed. When compared with 2011, the prices of commercial properties dropped 9.1% in 2012 (-7.1% for residential properties). When compared with 2012, the prices of commercial properties decreased -2.9% in 2013 (-1.9% for residential properties). This behavior has already been noted in the literature. For instance, Ellis and Naughtin (2010) point out the existence of a more severe decline in prices of commercial real estate compared to residential property in a number of countries, such as the United States, the United Kingdom or Spain. Factors such as the role of commercial real estate as an investment asset and its impact on financial institutions' balance sheets are pointed out by the authors as possible explanations for a more pronounced contraction in commercial prices during a recession period. Other explanations suggested by the authors may have to do with the fact that the construction of commercial property takes longer to complete than residential property. As such, lags between construction completion and demand for new spaces may occur. Additionally, excess supply takes longer to be absorbed following a recession. The ESRB (2015) also recognizes this larger cyclicality of CRE in comparison to housing and adds the existence of non-economic factors in housing purchases, as well as the financing structure of CRE and its higher correlation with capital markets, as possible explaining factors for the illustrated phenomenon.

6. Summary and conclusions

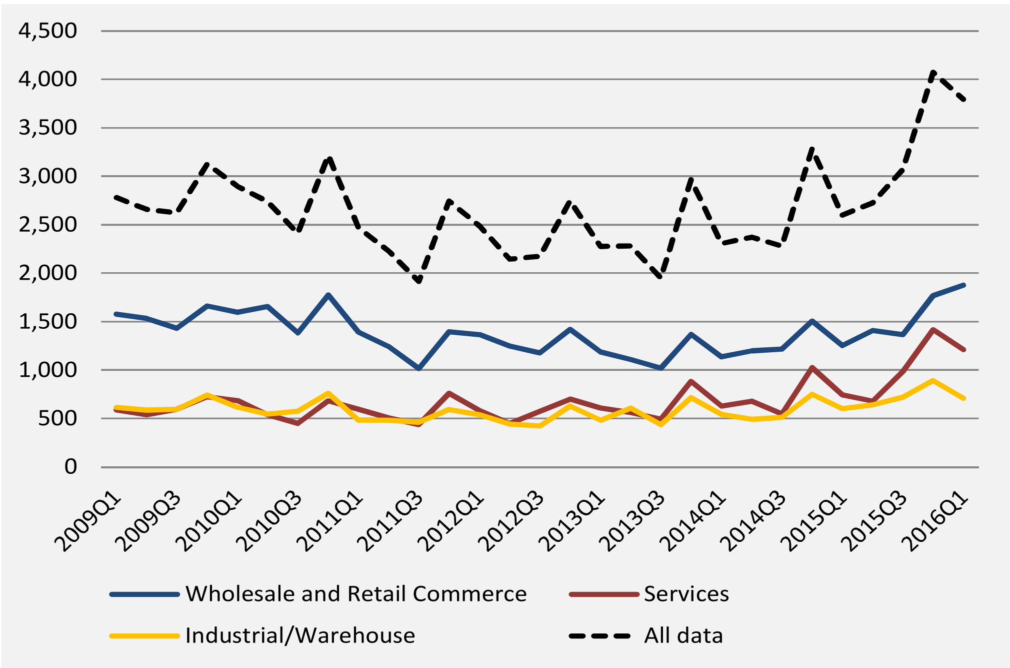
The need to gather information on commercial property prices based on transaction prices and representative of the whole Portuguese real estate market has led *Banco de Portugal* and *Instituto Nacional de Estatística* to combine efforts to produce new commercial real estate price statistics. This paper provides the results of a hedonically adjusted transactions-based CPPI, which had never been produced for Portugal. The choice of the compilation methodology, which is also applied in the compilation of the HPI, has proven to be adequate and supportive of regular production and dissemination of the new indicator in the short-term. The possibility of using administrative data sources for the compilation of the CPPI has also proven to be viable. The administrative data also allows for the compilation of other interesting statistics, such as the value and number of commercial property transactions. Based on this evidence, the *Instituto Nacional de Estatística* is planning to start the regular publication of CPPI data in 2017 (annual dissemination of data).

The result is a pioneering work that gives new insights into how commercial and residential property markets have evolved in Portugal since 2009. Although the results indicate a similar trend and turning points for the commercial and residential markets, it is interesting to note that the former asset prices have decreased more than the latter, during the recent financial crisis. This phenomenon is not new and has been reported in the literature for other countries. The differences found between the two asset classes are interesting and should be further investigated in the future.

Appendix 1. Dimension of real estate markets

Figure 1.1 Number of residential and commercial transactions and number of purchase and sale contracts

Figure 1.2. Number of transactions



Appendix 2. Commercial Property Price Index and HPI results

	Stratum indexes			Total Index			HPI
	Retail	*Services*	*Industrial*	*OLS*	*Median Quantile Estimator*	*Geometric Average*	
2009Q1	1.04	1.06	0.98	1.03	1.03	1.09	0.98
2009Q2	1.09	0.99	1.04	1.04	1.03	1.11	0.99
2009Q3	1.03	0.99	1.01	1.01	1.01	1.05	0.99
2009Q4	1.02	0.97	1.02	1.00	0.99	1.07	1.00
2010Q1	1.00	0.99	1.03	1.00	1.00	1.11	1.00
2010Q2	1.02	1.01	0.98	1.01	1.00	1.02	1.01
2010Q3	1.03	1.01	1.01	1.02	1.04	0.96	1.00
2010Q4	0.95	0.99	0.99	0.97	0.97	0.92	0.99
2011Q1	0.95	1.03	0.99	0.99	0.99	1.00	0.98
2011Q2	0.97	0.98	0.93	0.96	0.97	0.97	0.96
2011Q3	0.90	0.98	0.91	0.93	0.92	0.88	0.95
2011Q4	0.89	1.01	0.94	0.95	0.95	0.91	0.92
2012Q1	0.88	0.96	0.87	0.90	0.91	0.89	0.90
2012Q2	0.90	0.87	0.83	0.86	0.84	0.89	0.88
2012Q3	0.83	0.91	0.83	0.85	0.85	0.84	0.87
2012Q4	0.86	0.88	0.89	0.87	0.87	0.85	0.88
2013Q1	0.89	0.89	0.86	0.88	0.87	0.88	0.86
2013Q2	0.89	0.80	0.81	0.83	0.82	0.92	0.86
2013Q3	0.82	0.83	0.81	0.82	0.80	0.79	0.86
2013Q4	0.88	0.80	0.88	0.85	0.82	0.81	0.88
2014Q1	0.84	0.87	0.82	0.84	0.82	0.91	0.90
2014Q2	0.90	0.86	0.88	0.88	0.86	0.99	0.91
2014Q3	0.88	0.87	0.91	0.88	0.84	1.00	0.91
2014Q4	0.90	0.93	0.85	0.89	0.86	1.00	0.90
2015Q1	0.90	0.85	0.87	0.87	0.85	1.04	0.90
2015Q2	0.86	0.93	0.92	0.89	0.85	1.01	0.94
2015Q3	0.88	1.02	0.89	0.93	0.89	1.01	0.94
2015Q4	0.90	0.99	0.86	0.92	0.88	1.10	0.95
2016Q1	0.91	1.00	0.80	0.91	0.86	0.94	0.97
Mean	0.92	0.94	0.93	0.90	0.89	0.96	0.93
Stdev	0.071	0.074	0.074	0.067	0.074	0.091	0.050

Note: Base 1.00 = 2010.

Appendix 3. Summary of regression outputs

Table 3.1. Stability of parameter estimates across all regressions for Retail

	Average point estimate	*Stdev*	*Sign of parameter, no. of times, if statist. significant*	
			(+)	*(-)*
Intercept	7.403	0.236	28	0
LGrFloorA	0.840	0.039	28	0
DummyDep	0.193	0.042	28	0
DummyHuge	-0.144	0.131	0	12
DwTransAge	-0.011	0.002	0	28
SqAge	0.0001	0.00002	28	0
DNewBuild	0.134	0.053	24	0
DImprov	-0.036	0.115	2	6
DDistrCap	0.223	0.056	28	0
DLocBest	0.347	0.086	28	0
DSea	0.098	0.038	23	0
DReg1	-0.321	0.071	0	28
DReg2	-0.245	0.050	0	28
DReg3	-0.249	0.072	0	27
DReg4	-0.103	0.092	0	15
DReg5	-0.183	0.135	0	22
D10	0.071	0.206	10	0
D19	-0.091	0.147	0	6
D23	0.129	0.158	10	1
D37	-0.167	0.136	0	16
D47	-0.033	0.056	0	3
DOport	0.192	0.071	27	0
DIntLocGood	0.061	0.076	6	0
ClusterCom	0.240	0.084	26	0
DConstrQual	0.122	0.096	18	0
Minor	-0.154	0.087	0	21
DCSystem	0.128	0.110	15	0
DQi	-0.005	0.043	4	7

Notes: Average point estimates, standard deviation and statistics on the sign and significance of the coefficients are based on the results of 28 regression outputs. The model for Retail has a total of 28 parameters, 20 of which are statistically significant for more than half of the 28 regressions. The variables are defined in Appendix 4.

Table 3.2. Stability of coefficient estimates across all regressions for Services

	Average point estimate	*Stdev*	*Sign of parameter, no. of times, if statist. significant*	
			(+)	*(-)*
Intercept	*6.940*	*0.222*	28	0
LGrFloorA	*0.932*	*0.044*	28	0
DummyDep	*0.229*	*0.114*	24	0
DwTransAge	*-0.019*	*0.006*	0	28
SqAge	*0.0001*	*0.00006*	28	0
DAgeZero	*0.302*	*0.159*	23	0
DReg1	*-0.231*	*0.125*	0	20
DReg2	*-0.214*	*0.156*	0	20
DReg3	*0.197*	*0.198*	14	1
DReg4	*0.290*	*0.199*	24	1
DReg5	*-0.130*	*0.160*	0	8
DOport	*0.250*	*0.106*	22	0
DSea	*0.307*	*0.081*	28	0
DLocBestSer	*0.230*	*0.211*	16	0
D1	*0.212*	*0.178*	17	0
D17	*0.126*	*0.335*	9	3
D30	*0.204*	*0.185*	15	0
D45	*-0.205*	*0.232*	0	14
D44	*-0.139*	*0.164*	1	16
D47	*-0.035*	*0.123*	1	3
DDistrCap	*0.224*	*0.058*	27	0
DIntLocGood	*0.195*	*0.126*	20	0
Minor	*-0.173*	*0.134*	0	17
NFloorsBuild	*0.018*	*0.014*	20	1
DPropTot	*-0.154*	*0.147*	0	13
ClusterSer1	*0.273*	*0.170*	24	0
ClusterSer2	*0.143*	*0.229*	11	2
ClusterSer3	*-0.165*	*0.317*	3	11
DQi	*-0.002*	*0.054*	3	4

Notes: Average point estimates, standard deviation and statistics on the sign and significance of the coefficients are based on the results of 28 regression outputs. The model for Services has a total of 29 parameters, 21 of which are statistically significant for more than half of the 28 regressions. The variables are defined in Appendix 4.

Table 3.3. Stability of coefficient estimates across all regressions for Industrial properties

	Average point estimate	*Stdev*	*Sign of parameter, no. of times, if statist. significant*	
			(+)	*(-)*
Intercept	6.756	0.319	28	0
LGrFloorA	0.861	0.053	28	0
SqrtDepFloorA	0.009	0.005	19	0
SqrtPlotArea	0.002	0.001	13	0
DummyBig	0.032	0.085	3	0
DwTransAge	-0.014	0.004	0	28
SqAge	0.0001	0.00004	21	0
DNewBuild	0.129	0.091	17	0
NFloorsBuild	-0.024	0.014	0	13
DReg1	-0.386	0.108	0	27
DReg2	-0.425	0.120	0	27
DReg3	-0.355	0.126	0	25
DReg4	-0.031	0.144	0	1
DReg5	-0.135	0.133	0	4
DOport	0.213	0.082	25	0
DCity	0.136	0.053	24	0
DAirportPorts	0.120	0.139	7	0
DLocBestInd	0.237	0.094	23	0
D1	0.185	0.167	10	0
D26	0.038	0.101	2	0
D27	0.072	0.135	5	0
D51	-0.204	0.302	0	8
D53	-0.104	0.254	0	7
NDivisions	0.002	0.007	3	0
DBadCons	-0.157	0.202	1	6
DImprov	-0.083	0.081	0	3
DRebuild	-0.046	0.082	1	4
DAbsWater	-0.116	0.188	0	5
DAbsElectPow	0.005	0.267	1	2
DAbsSewa	-0.203	0.121	0	18
ClusterInd	-0.365	0.044	0	28
DQi	-0.007	0.048	1	2

Notes: Average point estimates, standard deviation and statistics on the sign and significance of the coefficients are based on the results of 28 regression outputs. The model for industrial has a total of 32 parameters, 14 of which are statistically significant for more than half of the 28 regressions. The variables are defined in Appendix 4.

Table 3.4. Number of observations and adjusted r-square, by type of commercial properties

	Retail		*Services*		*Industrial*	
	N	*Adj R-sq*	*N*	*Adj R-sq*	*N*	*Adj R-sq*
2009Q2	2,817	0.67	992	0.84	955	0.82
2009Q3	2,705	0.66	1,004	0.79	914	0.83
2009Q4	2,852	0.66	1,130	0.82	943	0.85
2010Q1	3,016	0.67	1,251	0.81	961	0.83
2010Q2	2,987	0.68	1,117	0.79	874	0.82
2010Q3	2,788	0.68	898	0.79	839	0.84
2010Q4	2,900	0.66	1,016	0.80	961	0.83
2011Q1	2,889	0.65	1,140	0.82	925	0.82
2011Q2	2,406	0.67	954	0.82	764	0.81
2011Q3	2,098	0.68	814	0.77	730	0.83
2011Q4	2,240	0.67	1,080	0.84	764	0.80
2012Q1	2,560	0.67	1,241	0.81	800	0.75
2012Q2	2,420	0.63	955	0.75	720	0.77
2012Q3	2,252	0.63	924	0.84	668	0.80
2012Q4	2,433	0.65	1,151	0.85	782	0.79
2013Q1	2,443	0.65	1,202	0.82	821	0.78
2013Q2	2,123	0.69	1,083	0.80	851	0.83
2013Q3	1,929	0.69	943	0.83	822	0.84
2013Q4	2,175	0.67	1,218	0.78	831	0.83
2014Q1	2,287	0.68	1,290	0.79	924	0.84
2014Q2	2,148	0.71	1,108	0.84	832	0.85
2014Q3	2,233	0.69	1,071	0.84	805	0.85
2014Q4	2,466	0.71	1,319	0.82	985	0.83
2015Q1	2,475	0.73	1,499	0.83	1,050	0.83
2015Q2	2,381	0.70	1,210	0.82	966	0.83
2015Q3	2,482	0.70	1,393	0.83	1,043	0.85
2015Q4	2,844	0.68	2,113	0.87	1,221	0.84
2016Q1	3,178	0.66	2,244	0.88	1,221	0.82

Appendix 4. Description of used variables

Explanatory Variable	***Variable Description***
Area Variables	
LGrFloorA	Logarithm of the gross floor area. The gross floor area is defined as the sum of all covered areas, as measured from the outer perimeter of the walls, with the same use as the residential unit.
DummyDep	Dummy variable equal to 1 if the property has dependent area, 0 otherwise. The dependent area is defined as the sum of all covered areas, including those located outside of the dwelling unit, which provide accessory services to the main use of that same dwelling unit. Garages, attics and cellars constitute typical examples of dependent areas.
SqrtDepFloorA	Square root of the dependent floor area.
DummyBig	Dummy variable if the gross floor area exceeds 300 square meters.
DummyHuge	Dummy variable if the gross floor area exceeds 500 square meters.
SqrtPlotArea	Square root of the plot area. The plot area is defined as the total uncovered land area, which is associated to an individual dwelling unit. This measure is net of the area in which the building of the dwelling unit sits on (i.e., the *Área de implantação do prédio*).
Age Variables	
DwTransAge	Age of dwelling at moment when the IMT is paid.
SqAge	Square of the age of dwelling at moment when the IMT is paid.
DNewBuild	Dummy equal to 1 if the dwelling age is zero years old and the dwelling has never been transacted previously.
DAgeZero	Dummy equal to 1 if the dwelling age is zero years old.
Location Variables	
DReg1	Dummy equal to 1 if the dwelling is located in NUTS 2 Norte; zero otherwise.
DReg2	Dummy equal to 1 if the dwelling is located in NUTS 2 Centro; zero otherwise.
DReg3	Dummy equal to 1 if the dwelling is located in NUTS 2 Alentejo; zero otherwise.
DReg4	Dummy equal to 1 if the dwelling is located in NUTS 2 Algarve; zero otherwise.
DReg5	Dummy equal to 1 if the dwelling is located in NUTS 2 Azores or NUTS 2 Madeira; zero otherwise.
DLx	Dummy equal to 1 if the dwelling is located in *Área Metropolitana de Lisboa;* zero otherwise.
Dsea	Dummy equal to 1 if the dwelling is located in a *Freguesia* near the sea; zero otherwise.
DLocBest	Dummy equal to 1 if the location is classified as exceptional by the IMI (*Coeficiente de Localização*). A location is considered exceptional if the *Coeficiente de Localização* is higher than 2.1 for Retail;2.5 for Services and 1.5 for Industrial.
Doport	Dummy equal to 1 if the dwelling is located in *Área Metropolitana do Porto*; zero otherwise.

Explanatory Variable	Variable Description
Area Variables (cont.)	
Dcity	Dummy equal to 1 if the dwelling is located in a City. The identification of a city is carried out using a list, which is available on the website of *Instituto Nacional de Estatística* (http://smi.ine.pt/Versao/Detalhes/3516). The boundaries of a statistical city are defined at the subsection level, the smallest statistical territorial unit for Portugal. For practical purposes, this variable was defined at the *Freguesia* level, with DCity assuming the value 1 if a *Freguesia* had at least one subsection defined as a city and 0 otherwise.
D ##	Dummy equal to 1 if the dwelling is located in "##" postal code area; zero otherwise. For instance, d12 is a dummy equal to 1 if the dwelling is located in "12" postal code area; zero otherwise.
DAirportPorts	Dummy equal to 1 if the dwelling is located near a port or an airport; zero otherwise.
DDistrCap	Dummy equal to 1 if the dwelling is capital of District (*Distrito*); zero otherwise. The *Distrito* is the first-level administrative subdivision of Portugal, whose mainland is divided into 18 *Distritos*. The cities of *Funchal* and *Ponta Delgada* were considered as capital of *Distrito* for the Madeira and Azores islands, respectively. The dummy variables were constructed using tables with a correspondence between *Freguesias* and capitals of *Distrito*.
Other variables	
DCSystem	The DCSystem is a dummy variable assuming the value 1 when the dwelling includes central heating and/or air-conditioning systems and 0 otherwise. It is derived from the quality element *Sistema central de climatização*, which is used to calculate the IMI's *Coeficiente de qualidade e conforto*.
DAbsWater	The DAbsWater is a dummy variable that assumes the value 1 when the access to public or private running water systems is inexistent in the dwelling unit and 0 otherwise. This dummy is derived from the *Inexistência de rede pública ou privada de água* factor, which is one of the *Elementos de qualidade e conforto* used in the calculation of IMI's *Coeficiente de qualidade e conforto*.
DAbsElectPow	Dummy equal to 1 when the property is not connected to public or private electric power distribution networks and 0 otherwise. This dummy is derived from the *Inexistência de rede pública ou privada de electricidade* factor, which is one of the *Elementos de qualidade e conforto* used in the IMI tax system.
DAbsSewa	The DAbsSewa is a dummy variable that assumes the value 1 when the property is not connected to public or private sewage systems and 0 otherwise. This dummy is derived from the *Inexistência de rede pública ou privada de esgotos* factor, which is one of the *Elementos de qualidade e conforto* used in the calculation of IMI's *Coeficiente de qualidade e conforto*.
NFloorsBuild	Number of floors of the building where the dwelling is located. The number of floors includes not only those located on or above the ground level but also all levels located below that same ground level.
DLiftEscalator	Dummy equal to 1 if the building where the dwelling is located has a lift/escalator. This dummy is derived from the *Existência de elevadores(s) e/ou escada(s) rolante(s)*factor, which is one of the *Elementos de qualidade e conforto* used in the calculation of IMI's *Coeficiente de qualidade e conforto*.
InteriorLoc	The InteriorLoc provides the values for the quality of the localization of the property relative to other properties located in the same building structure (*Localização e operacionalidade relativas*). The *Localização e operacionalidade relativas* parameter, which can assume positive (if the location is good) or negative (if the location is bad) values, is one of the factors that is used in the calculation of the *Coeficiente de qualidade e conforto*. The definition of *Localização e operacionalidade relativas* is given in number 2(n) of article 43 of the IMI tax code. The guidelines used in the attribution of *Localização e operacionalidade relativas* values are available in number 3 of article 43 of the IMI tax code. The *Localização e operacionalidade relativas* ranges from -0.05 to a maximum of 0.02. From this variable, two dummies were created. DLocIntGood, for positive values of InteriorLoc, and DLocIntBad, for negative values of InteriorLoc.

Explanatory Variable **Other variables (cont.)**	**Variable Description**
DBadCons	Dummy equal to 1 if the dwelling unit is in a bad conservation state, and zero otherwise. The variable that provides the values for the conservation state of the dwelling (*Estado deficiente de conservação*) is one of the quality and comfort factors (*Elementos de qualidade e conforto*) applied in the derivation of the quality and comfort coefficient (*Coeficiente de qualidade e conforto*). The *Coeficiente de qualidade e conforto* and its factors are defined in article 43 of the IMI tax code and is one of the six parameters that are used in the calculation of the *Valor Patrimonial Tributário.*
DConstrQual	Dummy equal to 1 if ConstrQual has positive values, and zero otherwise. The ConstrQual is the variable that provides values for the quality of the construction works (*Qualidade construtiva*), which is one of the *Elementos de qualidade e conforto* applied in the derivation of IMI's *Coeficiente de qualidade e conforto*. The dwelling features that have to be taken into account by appraisals experts in the attribution of a value for the *Qualidade construtiva* of a dwelling unit are given in the ministerial order n.er 982/2004 of August 4th. These include the quality of the project, thermal insulation, acoustic insulation, quality of building materials used at late construction works phases.
DImprov	Dummy equal to 1 if the reason for delivering the IMI tax declaration is an improvement (*"2. Prédio Melhorado / Modificado)*
DRebuild	Dummy equal to 1 if the reason for delivering the IMI tax declaration is a major improvement/rebuild (*"3. Prédio Melhorado/Modificado/ Reconstruído")*
Minor	Dummy equal to 1 if at least one of the minorants for the "Coeficiente de Qualidade e Conforto" is equal to 1. The minorants comprehend absence of toilet, no access to water, electric power, sewage, paved streets, lift in buildings with a number of floors higher than three, and bad conservation state DAbsToilet=1 or DAbsWater=1 or DAbsElectPow=1 or DAbsSewa=1 or DAbsPaved=1 or DAbsLift3=1 or DBadCons=1.
Major	Dummy equal to 1 if at least one of the majorants for the "Coeficiente de Qualidade e Conforto" is equal to 1. The majorants comprehend location within a shopping mall, an office building, existence of a lift or escalator, good construction quality and access to air conditioning. This is, the dummy variable is equal to 1 if DShoppMall=1 or DOfficeBuild=1 or DLiftEscalator=1 or DConstrQual=1 or DCSystem=1.
DPropTot	Dummy equal to 1 If IMI property type is a total building with no floors or divisions destined to independent use (*Prédio em Prop. Total sem Andares nem Divisão Susceptível de Utilização Indepedente);* zero otherwise.
ClusterCom (*)	Dummy equal to 1 if the transaction is located in a cluster of retail transactions; zero otherwise.
ClusterSer1 (*)	Dummy equal to 1 if the transaction is located in a cluster of services transactions; zero otherwise.
ClusterSer2 (*)	Dummy equal to 1 if the transaction is located in a cluster of services transactions; zero otherwise.
ClusterSer3 (*)	Dummy equal to 1 if the transaction is located in a cluster of services transactions; zero otherwise.
ClusterInd (*)	Dummy equal to 1 if the transaction is located in a cluster of industrial transactions; zero otherwise.

(*) Note: The construction of the cluster variables was based on the value per square meter of all commercial properties evaluated by the tax authorities. A national segmentation at a statistical section level was made with cluster analysis techniques. Portugal is divided into 18,074 sections. The clusters were reported by stratum.

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