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Appraising Old Buildings. The case of *Baixa Pombalina* (Lisbon's Historic Commercial Centre)

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1. Introduction

Property appraisal is currently an extremely important activity since the real estate market represents very large investments and is a major economic segment in any country. In this light, there is a need to acquire information and to produce knowledge about property appraisal methods to ensure that proper tools are used to provide the best results.

This work aims essentially to analyse the application of a multiple linear regression analysis model for appraising residential, commercial and service units located in Baixa Pombalina, Lisbon's historic commercial centre.

Preparing an appraisal model and comparing it with the currently used model is very relevant since this reveals whether property values applied until now are really the market values or if, perhaps, there is a more correct means of determining those values.

The goal is to have the new model provide better results by obtaining values very similar to market values and that, by comparison, will determine the current model's validity. In essence, the true aim is to analyse a rehabilitation operation's profitability based on exact and reliable information.

2. State of Art

Since the properties to be appraised are old, it must be understood that the generally applied methods may not be the most appropriate for appraising properties in Baixa Pombalina, a zone of extreme historical and cultural importance in the city of Lisbon. The buildings in this area represent a construction and architectonic style specific to the epoch in which they were built (construction began at about 1777 consequent to the 1755 earthquake).

Old buildings (a description which includes those over one hundred years old), contrary to recent buildings, may increase in value over time when their physical deterioration is no longer very relevant, that is, it when it no longer makes a relevant contribution to explaining the building's value.

The replacement cost method is the most common and recommended method for appraising old buildings.

The current method in use, in particular by Baixa Pombalina Sociedade de Reabilitação, to appraise buildings in Baixa Pombalina is based on the replacement cost method and the property tax calculation formula indicated in the Municipal Property Tax Code.

The said appraisal method consists of an analytical formula, as follows:

$$Vt = Vc \times A \times Ca \times Cl \times Cq \times Cc \times Cva \times Ct \quad (1)$$

Where:
Vt – current property value (which may be called the market value since that is what the formula aims to obtain) (€),
Vc – base value of the buildings, 615 €/m^2 according to ordinance 16-A/2008 of January 9,
A – gross building area (m^2),
Ca – use coefficient,
Cl – location coefficient,
Cq – quality and comfort coefficient,
Cc – condition coefficient,
Cva – architectonic value coefficient,
Ct – typology coefficient.

The values of these coefficients may be found in the Municipal Property Tax Code, in [1].

3. The zone under study

Baixa Pombalina has been occupied for 2,000 years, a fact that, on its own, may explain its historic importance. The site was once home to Romans and Arabs and was the commercial centre for the Portuguese maritime empire (15^{th} to 18^{th} century) and consequently became a multi-cultural mosaic. Nevertheless, a milestone in this zone's and Portugal's history was undoubtedly the earthquake of 1 November 1755. Until this date, Baixa Pombalina was

Lisbon’s political and commercial centre and home to the royal palace surrounded by a medieval and chaotic jumble of streets lined with shops. After the tragic earthquake, which also caused a tsunami and a vast fire, this zone was once again occupied.

The Pombaline buildings in their original design have very specific construction characteristics. However, it must be understood that, since Baixa Pombalina contains a vast number of very old buildings, the area reflects building techniques used during a broad period in history. Moreover, during the various epochs, the buildings were subject to adaptations, which explains the differences between this zone’s numerous buildings.

Next, we will look at the original construction characteristics of Pombaline buildings, since these features are totally or partly shared by nearly all the buildings in Baixa Pombalina.

As previously stated, the typical Pombaline building had 5 floors, including the ground floor and attic, and the façades were of the same height in each quarter and similar between quarters and on main streets of the same width.

Construction faced obstacles immediately at the start related to the foundations. As is well known, not only was the zone swept over by a tsunami, but the foundation soil is of an alluvial and muddy nature. This made it impossible to use direct foundations of stone masonry. The solution lay in using wood pilings, from 1 to 6 meters in length, forming a crib-like structure of wood posts covered with stone masonry.

The pilings, which are relatively small, are not meant to transmit the load to the harder ground below the mud and alluvial layers, although they help to improve this zone’s mechanical capacity (resistance and deformability) and enable the ground to support the actions induced by the buildings.

As for the building walls, each quarter has masonry walls along the exterior contour and around the central air shaft. The ground floor walls are about 90 cm thick. The main façade walls are transversely interconnected at the ground floor level by other stone masonry walls. Up to the first floor, the structure generally consists of stone arches and, from this level, the stone masonry is confined between a wood grate (in the interior) and the span’s square-stone frame (on the exterior). These parts are interconnected to provide a good connection between the building’s structural parts.

Above the first storey, Pombaline buildings feature a truly innovative construction method. The Pombaline “cage,” a three-dimensional bracing system, combining wood with stone masonry, provide a joint response to the loads. The wood’s flexibility safeguards against any movements caused by earthquakes, whilst the rigidity of the stone allows the structure to transmit the load to the ground more effectively.

The Pombaline “cage” is thus a three-dimensional bracing system consisting of Pombaline facing walls (interior walls about 15 to 20 cm thick), which are arranged both parallel and perpendicular to the façades. The parallel walls support the floor beams (also in wood) and the perpendicular walls are used as a connecting means between façades, gable ends and air shafts. Each unit’s number of rooms is limited by the number of Pombaline facing walls that, themselves, are limited by the plot’s depth.

It may be summarised that the Pombaline facing walls consist of 15x13 cm posts and 10x13 cm cross-members, and the free space between these parts is filled with stone or brick masonry, and both sides are finished in stucco plaster.

It is also worth noting that, in addition to this “cage” system, designed as a protection against earthquakes, other aspects were also taken into account in the construction of these buildings. For example, the concern with symmetry aspects, since a symmetrical building offers greater resistance to an earthquake than an unsymmetrical building, due to the more uniform redistribution of forces. Another example is the concern with detail in the interconnections between: orthogonal fronts; orthogonal fronts and masonry walls, by interposing wood cages and metallic parts; and walls and floors, through wall plates and counter wall plates.

In summary, the Pombaline building is a construction milestone for buildings in that epoch since, by including the wood grates in the façade walls, the Pombaline facing walls inside the building and the careful interconnection between them and the floors, provides a well thought out three-dimensional structure. The buildings were designed and built with detail in mind. For the first time, buildings were designed to withstand the usual stresses and also, fundamentally, earthquakes which, although exceptional, have a destruction capacity that must clearly be a major concern when designing any building.

As already stated, most Portuguese know that Baixa Pombalina is an extremely important zone in all aspects. It is also commonly known that this zone has been in decline, not only in the occupation of its units, but also its diminishing social and cultural importance in the “mindset” of Lisbon’s residents. As such, there is an urgent need to take action by defining strategies for this city zone so that it may gain new life and regain the prominence it deserves. One of those strategies is to rehabilitate the buildings.

It is also important to understand that this building rehabilitation strategy, whilst maintaining the location’s authenticity, will clearly have a very positive impact on the process to revitalise Baixa Pombalina, since this space already has a special place in the heart of Lisbon’s residents. To this end, this downtown area must fulfil people’s expectations in all aspects, including the offer of residential units, commerce and services in a zone that is favourable for carrying out any of the said activities.

There is thus a number of opportunities worth being studied in order to start this process. Next, some of the many opportunities applicable to this unique area will be pointed out:

– The possibility that the strong international tourism growth will benefit the Lisbon region, if it has a suitable offer which entails all the consequent beneficial impacts for the country;

– The pressing need to rethink whether it is necessary to maintain central state services in Lisbon's historic centre;

– The opportunity for a Baixa [downtown] under recovery to occupy a focal position in fulfilling a international investment potential which the city of Lisbon offers for creative industries, financial centres and real estate investment;

– The possibility of revitalising Baixa-Chiado, along with other historic zones through high quality urban life, thereby contributing to Lisbon's international appeal as a "university city" since there is currently a trend toward greater internationalisation in the higher education sector.

It is thus clear that a global study of this zone and of its real estate market is extremely important for appraising the respective buildings. In the Baixa Nascente [East Baixa], there is clearly a trend toward a higher service offer, a factor to be taken into account since residential use, for example, must not be overlooked.

An attempt is clearly being made to revitalise the zone, which also includes rehabilitating the buildings. But to revitalise, "attract" the interest of persons, it is necessary to also guarantee that the zone attracts them for various reasons. In other words, it is important to guarantee a good distribution of uses, otherwise the zone may be full of life at certain times of day and deserted at other times, something which is clearly not projected.

Consequently, the attempt to rehabilitate the buildings is of interest, not only to potential investors, but also to potential residents, or persons who are both potential residents and investors. Within this perspective, it is necessary to appraise the buildings to understand the profitability of a rehabilitation operation so that informed measures or actions may be taken in this regard.

4. The proposed model

The model explained

The proposed appraisal model is a multiple linear regression analysis model. A multiple linear regression property appraisal analysis is a comparative method. As such, this method uses a number of reference properties about which certain characteristics are known, including the value, in order to determine the value for any comparable property about which the same characteristics are known, except the value.

The univariable linear regression model expresses a relation between a dependant variable (Y) (thus called univariable) and one or more independent variables (X_i; i=1,...,p) and is shown by the following expression [X]:

$$Y_j = \beta_0 + \beta_1 X_{1j} + \beta_2 X_{2j} + ... + \beta_p X_{pj} + \varepsilon_j \ (j=1,...,n)$$

where:
Y_j= dependent, endogenous or explained variable;
X_j= independent, exogenous or explanatory variable;
$\beta_0,\beta_1,..,\beta_p$ = model parameters;
ε_j= random model errors;
n – the number of sample objects.

The multiple linear regression model must be based on the following base hypotheses:

a) the independent variable must be represented by real numbers not containing any random perturbation;

b) the number of observations, n, must be greater than the number of estimated parameters, that is, for the case of the simple regression, it must be greater than two;

c) the errors are random variables with an expected null value and a constant variance, that is, $E(\varepsilon)=0$ and $Var(\varepsilon)= \sigma^2$.

In preparing the model, used to predict the price of units in the Baixa Pombalina zone, the sales values of units collected from queries of real estate agencies were used as the depend variable values (price per m^2). It must be taken into account that these values are not a 100% representation of the market value to be estimated. However, and deducting the 5% real estate commission, we may consider that this value is very close to the market value.

Lastly, note that the collected values comprise a database used to obtain the multiple linear regression model's coefficients such that the model may estimate values for other units in the same situation, that is, comparable units.

Preparing the model greatly depends on defining the explanatory or independent variables. Taking into account the collected data and some sensitivity in the first approach, it was decided to define the following explanatory variables:

- Location;
- Use;
- Typology;
- Condition;
- Equipment and quality.

In defining independent variables, we are immediately faced with an imprecision, since these are qualitative variables, meaning that they are nominal. Processing independent variables using a multiple linear regression model is subject to more than one interpretation. According to João Maroco [2], a statistics expert, these variables may be processed and used only by applying auxiliary indicator variables, also known as "dummy" variables. According to Enrique Ballestero [3], a real estate appraisal expert, processing independent qualitative variables may be similar to what is performed for quantitative variables, provided levels or categories are defined for qualitative variables corresponding to numeric values. For example, in relation to location: Bad = 1; Reasonable = 2; and Good = 3.

Both methods have a justified utilisation basis. In the method using the dummy variables, the justification lies in not introducing any subjective information in the model, that is, if the location categories correspond to Street X = Bad Location; Street Y = Reasonable Location and Street Z = Good Location, the use of dummy variables attempts to impede the model from becoming automatically limited by the subjective fact that Street X is worse than Street Y, and therefore a property on Street X is less valuable than a property on Street Y. Moreover, if we assign a value of 1 to Street X, value 2 to Street Y and value 3 to Street Z, and we think of a simple linear regression, it is not obvious that a property on Street Z is worth 3 times more than a property on Street X, and that this relation is correct. Similarly, by using quantitative levels for qualitative variables in a multiple regression, there are no guarantees that introducing those levels in the model will produce good results since they are defined in a clearly subjective manner. Therefore, the method using dummy variables makes it possible to overcome these problems of subjectivity in defining the explanatory variables, and henceforth this method will be regarded as method A.

The method suggested by Enrique Ballestero [3] is based on defining quantitative levels or categories corresponding to qualitative differences. This method, henceforth called method B, is based on the principle that an appraiser with knowledge about the market may included these classes in the model without distorting the results. As such, qualitative variables may be assigned subjective values and therefore results in a simpler model with satisfactory results.

Since both methods seem valid and using the SPSS program (*Statistical Package for the Social Sciences* – a data processing and statistical analysis program) provides a fast evaluation of the results for both methods, a model will be created for each method and their results will be compared.

Defining the explanatory variables

We will now define the different segments for each independent variable already mentioned:

Location:
Level 3 – Main Streets;
Level 2 – Secondary Streets of Greater Importance;
Level 1 - Secondary Streets of Minor Importance.

Use:
Level 3 – Commercial;
Level 2 – Services;
Level 1 – Residential.

Typology:
Level 5 – Shops/Offices;
Level 4 – Studio/One-bedroom Apartment;
Level 3 – 2-bedroom Apartment;
Level 2 – 3-bedroom Apartment;
Level 1 – 4-bedroom Apartment or Greater.

Condition:
Level 4 – Good condition;
Level 3 – Requiring minor repairs;
Level 2 – Requiring renovation work;
Level 1 – Requiring structural and general work.

Equipment and Quality:
Level 3 – Very Good: Very good finish and equipment, central climate control, professional decoration, lift;
Level 2 - Good: Good finish and equipment, central climate control and lift, or property with the characteristics of level 3 but without a lift above the 3rd floor;
Level 1 - Reasonable: Reasonable finish and equipment or a property with the characteristics of level 2 but without a lift above the 3rd floor (this category includes buildings requiring general work or a more extensive renovation).

After this breakdown into levels of explanatory variables, it is necessary to explain why these variables were applied and the various corresponding levels.

Although a subjective definition, there is obviously a underlying logic to this process of defining and categorising the dependent variables.

In the case of the location variable, it seems clear that the Baixa Pombalina zone has streets that are “better” than others for owning a property. In regard to commercial units, it is clearly much better for a business to be located on Rua Augusta than on, for example, Rua de S. Nicolau, since the former has greater pedestrian traffic and is one of Lisbon’s landmarks.

In terms of use, we can also expect a difference in value between buildings which depend on their assigned use. In a zone where commerce and services reign over residential use, we can expect a building for commerce or services to be worth more than a residential building. Between commerce and services, the distinction may not be as clear. However, since this is one of Lisbon’s historic zones which attracts many visitors, a building for commercial use may be worth more than another under the same conditions but used for services.

The typology variable was included consequent to the property’s use in the formula adjusted for the property tax value already indicated in chapter 2. The justification for including the typology variable is explained in that chapter. However, we believe that it is not an essential variable for the model, but since the SPSS program can process a large number of data and this information is relatively easy, it was decided to include this variable in the model.

In principle, the building’s condition would be one of the most important variables in determining the building’s value. However, and after surveying the market, it was found that only the already mentioned levels could be included in the model, since there is a small number of survey data for buildings classified below 3. This aspect may be explained by the fact that in the real estate market it is extremely difficult to find data for units in poor condition. The sale of buildings in poor condition is not publicised since they are commonly associated to an investment operation by the purchaser or by both parties, the seller and purchaser.

The equipment and quality variable was created to distinguish buildings that, although they might have the same characteristics regarding location, typology, use and condition, have distinct characteristics regarding the overall quality and equipment. This distinction makes sense since, as an example, a unit with central climate control and a lift has a greater value than another without these features.

Model A

As previously stated, the procedure for Model A calls for defining independent dummy variables in order to overcome the subjectivity associated to introducing qualitative variables in a model that must be quantitative.

Therefore, it was necessary to define the following explanatory variables and conditions:

For Location:
L1 = 0;
L2 = 1 if the unit is level 2, otherwise L2 = 0;
L3 = 1 if the unit is level 3, otherwise L3 = 0.

For Typology: [T1, T2…refers to the number of rooms]
T1 = 0;
T2 = 1 if the unit is level 2, otherwise T2 = 0;
T3 = 1 if the unit is level 3, otherwise T3 = 0;
T4 = 1 if the unit is level 4, otherwise T4 = 0;
T5 = 1 if the unit is level 5, otherwise T5 = 0.

For Condition [EC]:
EC1 = 0;
EC2 = 1 if the unit is level 2, otherwise EC2 = 0;
EC3 = 1 if the unit is level 3, otherwise EC3 = 0;
EC4 = 1 if the unit is level 4, otherwise EC4 = 0.

For Equipment and Quality:
EQ1 = 0;
EQ2 = 1 if the unit is level 2, otherwise EQ2 = 0;
EQ3 = 1 if the unit is level 3, otherwise EQ3 = 0.

For Use [AF]:
AF1 = 0;
AF2 = 1 if the unit is level 2, otherwise AF2 = 0;
AF3 = 1 if the unit is level 3, otherwise AF3 = 0.

The following indicative auxiliary variables are thus defined, and these are the new explanatory variables: L2, L3, T2, T3, T4, T5, EC2, EC3, EC4, EQ2, EQ3, AF2 and AF3.

Consequently, the resulting model will be of the following type:

$$\text{Price/m}^2 = \beta_1 + \beta_2\,L2 + \beta_3\,L3 + \beta_4\,T2 + \beta_5\,T3 + \beta_6\,T4 + \beta_7\,T5 + \beta_8\,EC2 + \beta_9\,EC3 + \beta_{10}\,EC4 + \beta_{11}\,EQ2 + \beta_{12}\,EQ3 + \beta_{13}\,AF2 + \beta_{14}\,AF3 \quad (5)$$

Model B

It is extremely easy to define the explanatory variables for Model B, since this model does not alter variables or the levels already defined for these variables. That is, the definition of explanatory variables is the one already adopted, whereby all the necessary data for processing the regression are already entered in the SPSS program.

The consequent model will have the following generic formula:

$$\text{Price/m}^2 = \beta_1 + \beta_2\text{LocationLevel} + \beta_3\text{TypologyLevel} + \beta_4\text{ConditionLevel} + \beta_5\text{EquipmentQualityLevel} + \beta_6\text{UseLevel}$$

The following analyses were performed to improve the created models:

- residue analysis, used to remove data about units that are not applicable to the real estate market of Baixa Pombalina;
- analysis of "best model"/selection of variables, in order to reduce the explanatory variables to merely those making it possible to explain the values in the best manner.
- analysis of the variable collinearity.

Final Models

The conditions have been created to present the final models, which will make it possible to appraise units in Baixa Pombalina according to a market approach.

Next, the final results provided by the SPSS (figures 1 and 2) and each model's formula will be presented.

Model A

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	,861a	,742	,711	436,20895

a. Predictors: (Constant), AF3, L3, EC4, T2, T4, AF2, EQ3

ANOVAb

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3,276E7	7	4,680E6	24,597	,000a
	Residual	1,142E7	60	190278,246		
	Total	4,418E7	67			

a. Predictors: (Constant), AF3, L3, EC4, T2, T4, AF2, EQ3
b. Dependent Variable: Precom2

Coefficientsa

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	1488,669	130,831		11,379	,000
	L3	587,087	149,079	,268	3,938	,000
	T2	552,645	156,065	,270	3,541	,001
	T4	427,684	192,694	,171	2,219	,030
	EC4	595,162	123,669	,359	4,813	,000
	EQ3	514,224	143,790	,281	3,576	,001
	AF2	476,162	155,371	,239	3,065	,003
	AF3	1262,202	169,317	,616	7,455	,000

a. Dependent Variable: Precom2

Figure 1 - SPPS output with the final results of model A

Formula:

Price/m^2 = 1488,669 + 587,087 x L3 + 552,645 x T2 + 427,684 x T4 + 595,162 x EC4 + 514,224 x EQ3 + 476,162 x AF2 + 1262,202 x AF3 (2)

Model B

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	,787a	,619	,595	516,98946

a. Predictors: (Constant), Afectacao, EstadoConservacao, Localizacao, EquipamentosQualidade

ANOVAb

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2,734E7	4	6,835E6	25,573	,000a
	Residual	1,684E7	63	267278,099		
	Total	4,418E7	67			

a. Predictors: (Constant), Afectacao, EstadoConservacao, Localizacao, EquipamentosQualidade
b. Dependent Variable: Precom2

Coefficientsa

Model		Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Tolerance	VIF
1	(Constant)	-115,685	354,421		-,326	,745		
	Localizacao	318,943	103,853	,259	3,071	,003	,853	1,173
	EstadoConservacao	186,698	94,107	,200	1,984	,052	,598	1,672
	EquipamentosQualidade	337,993	105,493	,337	3,204	,002	,548	1,824
	Afectacao	522,444	91,692	,512	5,698	,000	,749	1,336

a. Dependent Variable: Precom2

Figure 2 - SPPS output with the final results of model B

Formula:

Price/m^2 = -115,685 + 318,943 x Location + 186,698 x Condition + 337,993 x EquipmentQuality + 522,444 x Use (3)

5. Model Validation and Analysis of Results

Validating the Model's Presuppositions

The residue analysis is a means of validating the presuppositions for applying the linear regression model:

- the errors have a normal distribution with a null average and constant variance;
- the errors are independent.

The SPSS makes it possible to confirm the first presupposition through a simple graphic analysis. In an ideal situation, the errors or residues, when represented graphically according to their y_j values (price/m^2 values resulting from the regression model), are distributed in a random manner in relation to $e_i = 0$ (error equal to zero), of which the following plot is an example (figure 3):

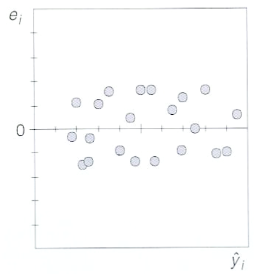

Figure 3 – Plot representing the ideal error distribution [2]

The normal error distribution may be confirmed graphically through the normal probability plot which may also be obtained through the SPSS. If the errors have a normal distribution, then the values represented in this plot should be distributed somewhat along the main diagonal line, of which figure 4 below is an example:

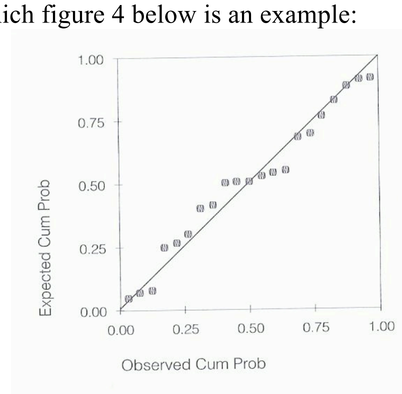

Figure 4 – Normal probability plot representing a normal error distribution [2]

The presupposition that the residues are independent may be confirmed through the Durbyn-Watson coefficient, which may have values from 0 to 4. If this coefficient is close to 2, then the independence of the residues is guaranteed. This coefficient may also be obtained automatically through the SPSS.

Since the SPSS makes it possible to obtain a plot of residues vs. values, of normal probability and the Durbyn-Watson coefficient, it is then possible to confirm whether the presuppositions are met for both models.
The results for both models are presented below.

Model A

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	,861[a]	,742	,711	436,20895	1,926

a. Predictors: (Constant), AF3, L3, EC4, T2, T4, AF2, EQ3
b. Dependent Variable: Precom2

Figure 5 – SPPS output for model A in which the Durbin-Watson coefficient stands out

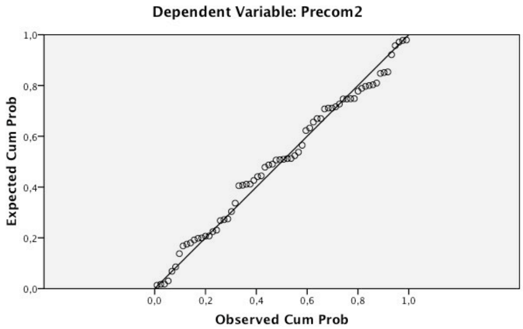

Figure 6 – Normal probability plot for model A

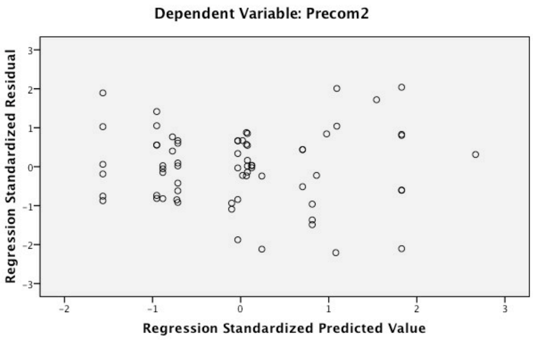

Figure 7 – Error distribution plot for model A

Model B

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	,787[a]	,619	,595	516,98946	1,570

a. Predictors: (Constant), Afectacao, EstadoConservacao, Localizacao, EquipamentosQualidade
b. Dependent Variable: Precom2

Figure 8 – SPPS output for model B in which the Durbin-Watson coefficient stands out

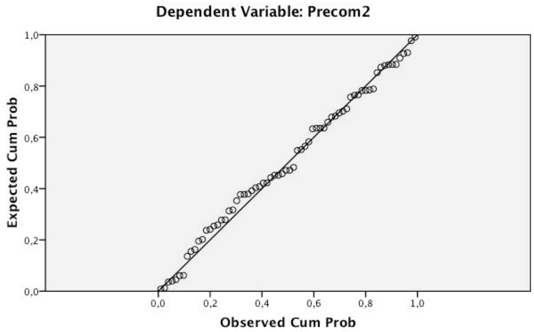

Figure 9 – Normal probability plot for model B

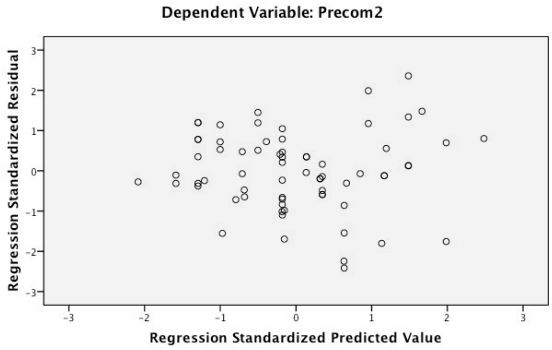

Figure 10 – Error distribution plot for model B

As revealed through an analysis of the above results, both models meet the presuppositions for applying the linear regression model. Thus, they are valid and reveal a good capacity to explain the reality under study (real estate market of Baixa Pombalina), whereby for Model A - R^2 = 0,742 and R^2_a = 0,711 and for Model B - R^2 = 0,619 and R^2_a = 0,595.

Analysis of the Results

We may perform the comparative analysis of the results obtained by method A, method B and the adapted formula (current method) by studying the indicators shown in the following table:

Table 1 – Statistical indicators of the models

	EQM FA	EQM RLMA	EQM RLMB
Average relative error % of the estimated market value	49,0	36,3	36,5
Price/m² absolute error average	981	322	392
Value absolute error average	97950	39994	47295
EQM of estimated price/m²	1122	410	498
EQM of estimated market values	115697	66554	74791

Where the EQM is the mean quadratic error.

It is thus found that Model A produces the best results, and Model B also produces satisfactory results. As for the currently used model, the analytical formula, it was found that it tends to produced values below the market value, since it is based on the formula for calculating the property tax value which can be expected to be always lower than the market value.

We may thus state that the proposed models perform well in providing estimated values similar to the sample's exact values. Since the sample represents the market, it may be concluded that the models also provide a good estimate of the market value of residential, commercial and service units in the Baixa Pombalina zone.

In comparison with the previously used method, it is clear that the latter produces values below the market value and, consequently, must be used judiciously and for the respective appraisal purposes (e.g. bank loan). If the market value is to be obtained for a sales transaction, then either of the proposed models is regarded to be the best alternative.

6. Conclusion

In conclusion, it may be stated that, in addition to their good results, the models are extremely simple to apply and the SPPS user may update the models when there is more available information. That is, a regression analysis model to appraise a specific number of properties may be continuously updated according to the availability of additional information about the transactions of those properties. In reality, this makes it possible to create a complete model which is highly capable of explaining the real estate market to which it is applied.

It is also worth noting that, due to its user friendly nature, this type of model is more useful for medium/large scale appraisals. When appraising merely one specific building, using at least another appraisal method should be taken into account in order to understand whether the values obtained through the regression analysis model are similar to the desired value. Nevertheless, if the model is extremely complete and is prepared based on correct and representative market data, it may be considered that the application of a method based on the regression analysis is a recommendable practice.

As for the limitations and aspects to be improved in the created models, it is essential to understand that the more representative the information, provided it is quality information, the better the model. In the created models, 75 property units were used for data input, which is clearly insufficient for a market comprising 4,483 units. This is explained by the fact that the information necessary for developing this type of model is extremely scarce and, when it is available, it is difficult to access since valuable information is not easily shared. The low information volume also arises from the effort to consult only reliable sources and since not many properties were sold during a short period, of about 8 months. It may thus be asked why uniform values were not used from previous transactions. These values were not used because this information is extremely difficult to obtain. Real estate agents do not disclose this information to protect their own and their clients' interests, and the officially declared values tend to always be lower than the real sales values in order to decrease the applicable taxes. Consequently, the choice that seemed the most suitable was to use sales values for properties presented by the real estate agents minus the 5% sales commission. This practice may be questioned, since there is no absolute guarantee that these values represent the market value. Nevertheless, it is believed that this corrected sales value is the asking price by an informed seller from an informed purchaser, which is essentially the definition of market value.

It is thus clear that one of the aspects to be improved will be the quantity of information to be used to make the models even better and with greater power to explain the market.

One of the limitations to be raised about the model is that it may be used to estimate values only for units in relatively good condition or not requiring very intensive work, since these are the units currently being sold. To estimate the value of units in poor condition, the proposed model could be used provided we also knew the cost necessary to rehabilitate those units. It would be necessary to merely subtract the cost of rehabilitating the unit in its real condition from the unit's rehabilitated value. This approach may provide better results than applying the said analytical formula, which estimates the values of units in poor conditions but that, nevertheless, produces results with some limitations.

It is necessary to understand that nothing is definitive and, as such, is always subject to improvement. In this light, the created models may be substantially improved by inputting quality information. The process of preparing an extremely complete model may take a long time and requires constant information adaptations, in particular by ensuring uniform values on the date on which the appraisal is performed. As such, in the future the proposed models could be continuously improved and developed in order to become more comprehensive and to produce even more reliable results.

It would also be of great interest to apply the multiple linear regression analysis comparative method to a real estate market providing a fuller range of information necessary for the model, and to test, during a relatively long period, the results produced by the created model in order to understand the deviations from the actual sales values.

An obvious complement to the created model would be to prepare a model to estimate the cost of rehabilitating the units, since using both models jointly would estimate the market value of units in poor condition more precisely and would portray the real estate market in a more realistic manner.

As already mentioned, possessing knowledge when appraising real estate is extremely important and, due to the innovative nature of the developed model and the study carried out, it is necessary to continue producing knowledge in this area to help improve the respective practices and tools. In this manner, the highly important real estate market may contribute to economic development.

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