EVALUATION AND DEPRECIATION ANALISYS OF THE IMMOBILE MARKET VALUE IN THE CITY OF CODÓ-MA.

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Abstract

Due to the heterogeneity of the real estate market and its peculiarities, it is not always possible to develop a single model that is totally faithful and representative of the market reality, thus, the Evaluation Engineering is increasingly developing, with the use of increasingly advanced processes in the determination of the value of the good, such as the application of statistical inference and the use of physical depreciation. This study aims to determine the value of a property in the city of Codó-MA, using statistical inference through multiple linear regression and, later, to verify physical depreciation. The data were collected in the city of Codó,MA, in real estate, construction companies that work with the sale of houses, ads and, its statistical treatment was performed by the Sisdea software. After the statistical treatment some models were generated and the most effective one was used and the one that best met the requirements foreseen by NBR 14653-2 (2011) and, after the physical depreciation was verified by two different methods: survey of the cost of recovering the good and Ross Heidecke's method. Finally, it was possible to determine the market value of the property and to make a critical analysis among the values found of physical depreciation by each method performed.

Keywords: Statistical inference, physical depreciation, multiple linear regression, immobile.

1. Introduction

According to Dantas (2003) the evaluation engineer is an engineer specialist that combines an extensive set of knowledge of the architecture and engineer area, as well as in the other areas of science like social, exact and nature. Its goal is to estimate the value of a property, its rights, its profits and production cost, whether it's an urban property, rural, equipment, machinery, enterprise, assets of estates and artistic.

According to the Brazilian regumentory standard (NBR) 14653-1 of the ABNT (2019) the first technical works about evaluation of a property in Brazil appeared in the 1910 decade, in publications of engineer schools and public repartitions dedicated to tributation, management and services contracting and works in big capitals.

The evaluation engineer in Brazil has been growing and evolving in the evaluation techniques, currently a large number of professionals has been developing studies in the field, giving scientific support as support to the technique's methods. (FIKER, 2008).

According to the NBR 14653-1 (2019), the main methods to identify the property value, its profits and rights are: evolutionary method, direct comparative method of market data, income capitalization method and unevolutionary method. The most common method used in real estate evaluation is the direct comparative method of market data, that is based on gathering data, analyses and data modeling of the real estate market. (GONZÁLEZ, 2002).

To Dantas (2003) other important factor that must be considered in a property evaluation and that can alter its value, is the depreciation, that can be physical order or functional. The physic depreciation suffered throughout its existence, its conservation state and the functional depreciation occurs by project mismatch, from concept failures or construction, are the extrinsic and subjective causes (CAVALCANTI, 2002).

The project has as goal, search for factors that influence and support in the evaluation determination of the property value, so, it is intended to demonstrate that the statistics interference, applied to the multiple linear regression. Can offer satisfactory results and the quantity determination of the physic depreciation on the property. This way, the present study contributes positively in the evaluation engineer, approaching not only the multiple linear regression, under the property market value, but also the use of the physic depreciation. It is also important to emphasize that this paper was produced during the Covid-19 world pandemic, this way making it impossible the inspection of all the data that compose the sample, that led to the use of the physic depreciation in an innovative way.

This paper has as goal to determinate the value of a property in the city of Codo-Ma, using the statistical inference through the multiple linear regression and subsequently, verify the physic depreciation. In addition, it is intended to obtain the level of detail minimun II and the level of precision III when using the multiple linear regression model, evaluate the physic depreciation level by the asset recovery cost evaluation method and by the Ross-Heidecke method and lastly establish a critical analysis of the physical depreciation between the two methods presented, looking to relate them, even that the property value has been defined by statistic inference.

2. Literature Review

2.1 Method to identify the property, its profits and rights

2.1.1 Straight market data comparative method

According to NBR 14653-1 (2019) the data comparative method identify the property market value through technical treatment fo the comparable elements characteristics, constituents within the analyzed samples, in other worlds, consists in obtain a property data sample with characteristics, in preference, similar to the evaluated property.

This method is extremely benefic in the land evaluation, in which elements can be directly treated, making them comparable (FIKER, 2008). In other hand to use this method it is necessary to exist a similarity to direct comparison or homogenized parameters application to the data transposition of the searched batches to the evaluated batches (ABUNAHMAN, 2008).

Due to the difficult to find interesting elements, started to do homogenization using elements not very similar, with this the results obtained caused a distortion of value in the market reality, since that it was used subjective aspects in the homogenization (BAPTISTELLA, 2005). This way, it is up to the evaluation professional to determinate through its analyses the most viable method and that best fits to what is being evaluated.

2.1.2 Involutive method

According to the NBR 14653-1 (2019) the involutive method identify the property value, based on its efficient exploitation, based in the study model and technical-economic viability, through hypothetic compatible enterprise with the property characteristics and with the marked condition which is entered, considering possible scenarios both for execution and commercialization.

It is also known as residual method or efficient maximum utilization method, requires from the evaluator a marked knowledge of the ended product (urbanized lots, edifications) to calculate the final residue, a massive study and comprehension of all the obtained data (ABUNAHMAN, 2008).

2.1.3 Evolutionary method

In concordance with the NBR 14653-1 (2019) the evolutionary method determinate the property value by the values summation of its components, in other worlds, considering all the elements that influence the construction cost and the sells price. In case that the finality is the market value identification, it is important to consider the commercialization factor.

It can be said that while the involuntary method is calculated the property value from the expected receipts, in the evolutionary method it is calculated the property value from the obtained costs (BAPTISTELLA, 2005).

2.1.4 Capitalization of income method

In concordance with the NBR 14653-1 (2019) the capitalization of income method identifies the property value, based in the current capitalization of your expected net income, where are considered viable sceneries during is use, in other words, this procedure is based in the principle that the value of a specific asset that is related with its ability to generate income.

When using the income method, the property rentability is explicit what makes comparable to investments in others kind of properties and also in other actives, such as savings account, stocks, etc. Therefore, the necessary data to the utilization in this method are the expected receipts, the refunds, the discount fee and the investments period number. (BAPTISTELLA, 2005).

2.2 Methods to identify the cost of a property

In concordance with the NBR 14653-2 (2011), the most common methods to identify the costs of a property, are:

- **Direct Cost Comparison Method:** It is considered a sample that contains properties with similar projects, with comparable elements, from this are elaborated models that follow the used procedures in the comparative data method.
- **Cost Quantification Method:** it is used to identify the reedition cost of the improvements. Can be performed by analytical budget. With citations of all used sources, and through the basic construction unitary cost.

2.3 Variable's classification

In the evaluation engineer it is considered as variable depends on the market price, being specified based in the total price or in the unitary price, usually monetary measured per m2 in are. As for the independent variables that are responsible by the markets price on the sample collect, correspond to the physical characteristics (area, front, pattern, etc), localization (tax index, urban sector, distance to influential poles) and temporal (PELLI NETO, 2006).

According to NBR 14652-2 (2011) the independent variables can still be basically divided in four groups:

- **Quantitate variable:** ca be counted or measured. For example: front constructed area, total area, etc.;
- **Quality variable:** cannot be counted or measured, but only hierarchized or ordained. For example: The property conservation state, when using some kind of chart, like Ross-Heidecke, that estimate the property depreciation percentage;
- **Proxy variable:** it is utilized to substitute other of hard measure, obtained by inferred indicators or published in other market studies. For example: Fiscal index
- **Dichotomous variable:** assumes only two positions. They are generally used to indicate the absence of permanence of a certain attribute in the sample. For example, flooring (yes:1 no:0).

2.4 Physical depreciation

According to 14653-2 (2011), the physical depreciation is due to the detriment of the several parts that constitutes the edification the calculation can be done in a analytical formal (by property restauration budget in the condition of new), or by applying depreciation coefficients (consecrated methods), that takes into consideration the age and conservation state.

The choice of which way to calculate the physic depreciation still implies on the foundation of the evaluation can be grade III, grade II and grade I, according indicated on the Chart 1 that can be found in the NBR 14653-2 (2011).

Chart 1 - Degree of substantiation in the case of using the method of quantification of the cost of improvements

Item	Description	Degree		
		III	II	I
1	Direct Cost Estimate	By budget elaboration, at least synthetic	By basic unitary cost use to similar project to the standard project	By basic unitary cost use to a different Project of the standard project, with its proper adjustments
2	BDI	Calculated	Justified	Arbitrary
3	Physical depreciation	Calculated by property recovery cost survey, to leave it in as new condition	Calculated by consecrated technical methods, considering age, useful life and conservation condition.	Arbitrated

Source**:** BRAZILIAN TECHNICAL STANDARDS ASSOCIATION (2011).

It is considered the useful life as a period of time which a build an its systems provide for the activities which were planned and built, considering periodicity and the right execution of the maintenance, under satisfactory safety, health and hygiene conditions. The estimated useful live can be observed according to the specified pattern to the property, as illustrates the Table 1.

In according to the NBR 14653-2 (2011), the property apparent age is the age attributed to reflect its functionality, use, used materials. It differs from the actual age that is the elapsed time since the conclusion of the construction until some reference date.

Table 1 - Useful life and residual value for the types of properties.

Group	Pattern	Useful life (Years)	Residual Value (%)
Shed	1.1 – Rustic Pattern	5	0%
	1.2 – Simple Pattern	10	0%
House	2.1 – Rustic Pattern	60	20%
	2.2 – Proletarian Pattern	60	20%
	2.3 – Economic Pattern	70	20%
	2.4 – Simple Pattern	70	20%
	2.5 – Medium Pattern	70	20%
	2.6 – Superior Pattern	70	20%
	2.7 – Thin Pattern	60	20%
	2.8 – Luxury Pattern	60	20%

Source: Adapted from IBAPE SP – Building values of urban real estate – isoleted unity (2019)

2.5 Ross-Heidecke depreciation model

It's about a mix method, considering the age (Ross) and conservation state (Heidecke). According to Dantas (2012), the depreciation value calculated by the Ross-Heidecke method, can be found from the following equations:

$$D = [\alpha + (1 - \alpha) * c] * Vd \quad \text{Eq.1}$$

Where:

D is the total depreciation

C Is the Heidecke Coefficient

Vd is the depreciation value, that would be the diference between the reproduction cost and its residual value, given by the equation:

$$Vd = CR - R \quad \text{Eq.2}$$

Where:

CR is the reproduction cost

R is the residual value

α is the depreciation part by effective or current property age (Ross), given by the equation:

$$\alpha = \frac{1}{2} * \left(\frac{x}{n} + \frac{x^2}{n^2}\right) \quad \text{Eq.3}$$

Where:

X is the property age;

N is the property useful age.

Heidecke defined a new conservation state scale, in percentage, where 0,00% corresponds to "new" and '00% corresponds to "no value", to make it easier to calculate the depreciation coefficient of a new property with its age in life percentage, is illustrate in the chart 2.

Chart 2 - State of conservation scale

Ref.	Edification State	Depreciation (%)	Characteristics
A	NEW	0,00%	New edifications or with substantial reform and general with less than 2 years, that shows only signs of natural wear, of external paint.
B	BETWEEN NEW AND REGULAR	0,32%	New edification or with substantial reform and general, with less than 2 years, that presents necessity only of a small painting.
C	REGULAR	2,52%	Semi new edification or with substantial reform and general between 2 and 5 years, that can be recovered Only with repairs of eventual superficial cracks localized and/or external and internal paint.
D	BETWEEN REGULAR AND SIMPLE REPAIR	8,09%	Semi new edification or with substantial reform and general between 2 and 5 years, that can be recover with cracks and breaks repairs localized and superficial and external and internal paint.
E	SIMPLE REPAIR	18,1%	Edifications that can be recovered with external and internal paint, after generalized superficial cracks and breaks repairs, without system recover. In the future, overhaul of the hydraulic and electrical system.
F	BETWEEN SIMPLE AND IMPORTANT REPAIRS	33,2%	Edifications that can be recovered with external and internal paint, after cracks and breaks repairs, with stabilization and/or localized recover of the structural system. The electric and hydraulic installations can be restored through review and with the eventual replacement of some naturally worn parts. In the future can be necessary substitution of the revetments of the walls and floor, of one, or other room. Impermeabilization or roof tiles replacement review.
G	IMPORTANT REPAIRS	53,6%	Edifications that can be recovered with external and internal paint, with masonry regularization panels substitution, cracks and breaks repairs, with stabilization and/or large structural system recovery. The electric and hydraulic installation can be restored by replacement of apparent parts. The substitution

			of the walls and floor coating, of most of the rooms, is needed. Important repairs of the roof or impermeabilization.
H	BETWEEN IMPORTANT REPAIR AND NO VALUE.	75,2%	Edification that can be recover with structural system recovery and/or stabilization, masonry regularization substitution, cracks and breaks repairs. Hydraulic and electric installation substitution. Floor and walls coating substitution. Impermeabilization or roof substitution.
I	NO VALUE	100%	Building in a state of disrepair.

Source: IBAPE SP- Building values of urban real estate - isolated units (2019).

2.6 Statistic inference

The statistic inference is a set of techniques that has as goal study the population through evidences provide by a sample, that contains elements that can be analyzed and, from that, amounts of interest can be obtained (MAGALHÃES; LIMA, 2008). Within valuation engineering the statistic inference consists in aim to the evaluation, once that cannot be subjective, and provides in a more direct opportunity the search of the marketing truth.

It is important to emphasize that to the evaluator the professional knowledge in evaluation and statistics will avoid the inclusion of the inadequate variables or the absence of important variables, and that in the model selection to be used, this must represent, in the possible measure, the complexity that involves the real population world in study, as well as the market randomness (BOLFARINE; SANDOVAL, 2010).

According to Baptistella (2005), the introduction of the statistic inference in the Brazilian evaluation engineer corresponded to an attempt to solve or lessen problems, for example the subjectivity involved in the homogenization. The statistic inference can vi applied in the multiple linear regression, in combination with hypothesis test, the confidence interval, significance level, etc.

2.7 Multiple linear regression model

The multiple linear regression is the method that involves the relation between a dependent variable and two or more independent variable, through an established role. In Valuation Engineering usually we work with multiple linear regression models, given the multiplicity of factors that can interfere on the prices of a property (DANTAS, 2003).

According to Baptistella (2005), the multiple linear regression model is the evaluators' favorite, for its efficiency, but due to its variations, the model's complexity, and the lack of knowledge about the relation between the variables, the analyses of the data can be compromised.

The real estate market variability can be explained by a dependent variable and several independents' variables, using to analyze a multiple linear regression model. The steps to build a regression model to explain the price of a property are: identify the independents variables; transform the variables; data gathering; explanatory analysis; model construction; critical analyzes of the variables; residue analyses and verify the model's applicability (GAZOLA, 2002).

The generic model is given by the equation (Eq.4) according to LEVINE et.al. (2005), when applied in a sample of size n:

$$y_i = \beta_0 + \beta_1 x_{1i} + \beta_2 x_{2i} + \cdots + \beta_k x_{ki} + \varepsilon_i, \quad i = 1, 2, \ldots, n \quad \text{Eq.4}$$

Where:

yi = dependent or explained variable;

β0 = variable independent term;

β1 = Y inclination regarding the variable X1, maintaining constant the variables X2, X3, ..., Xk;

β2 = Y inclination regarding the variable X2, maintaining constant the variables X1, X3, ..., Xk;

βk = Y inclination regarding the variable Xk, maintaining constant the variables, X1, X2, X3, ..., Xk-1;

εi = random mistake in Y, to observation i, i = 1,2, ..., n.

The multiple linear regression that describes the relation between the dependent variable and the independent variables will be provide by the software, SisDEA, using this present paper. Through the SisDEA also will be provide the confidence interval range, the regressors significance level and the model, the determination coefficient and the correlation, the model residue graphic, the correlation, between the independent variables, among other determinants factors on the choice of the best multiple linear regression model.

2.7.1 Hypotheses test

The Hypotheses test has as goal to verify the possibility of mistakes been made on the affirmations about the populational average or, inside the real state evaluation, under the influence of a variable over another. The hypothesis is a conjecture, that according to certain criteria can be rejected or not-rejected (PELLI NETO, 2003).

So, the hypotheses test goal is to provide a methodology that can allow to verify if the sample data provide evidence to support or not a formulated hypothesis. (MORETTIN; BUSSAB, 2012).

2.7.2 Trust interval

The trust interval provides information about the estimation accuracy, it is from that that it can be confirmed, if the trust interval establishes limits to the value of the study object (GAZOLA, 2002). So, the trust interval is a way to calculate an estimative of an unknown parameter, that many times works as a hypotheses test.

According to Mendonça et.al. (1998) the trust interval for a multiple regression is the one with the smallest amplitude within the calculated intervals to each regressor. Within the property evaluation to reach certain precision degree, values must be reached indicated by the NBR 14653-2 (2011), illustrated in the Table 2.

Table 2 – Accuracy degree of the value estimation when using the linear regression model

Description	Degree		
	III	II	I
Trust interval amplitude of 80% around the central tendency estimate	≤30%	≤40%	≤50%

Source: BRAZILIAN TECHNICAL STANDARDS ASSOCIATION (2011).

2.7.3 Significance level

The significance level, to evaluation engineer through regression model is indicated by the NBR 14653-2, according to the evaluation foundation degree, indicated in the Table 3.

Pelli Neto (2003) defines the significance level as the probability to occur errors when rejecting a true hypothesis, therefore, is of utmost importance that this probability is small. In other words, the higher the significance value, the more likely the error will occur.

Within the property evaluation the intention when formulated the hypotheses that a variable have influence over the value, is to show that exists great possibility of being right, so it is necessary that the significance level be reduced.

Table 3 - Significance level

5	Significance level (two tails value sum) Maximum for the rejection of the null hypothesis for each regressor (two-tailed test).	10%	20%	30%
6	Maximum significance level admitted for the rejection of the null hypothesis model through the F test of the snedecor	1%	2%	5%

Source: BRAZILIAN TECHNICAL STANDARDS ASSOCIATION (2011).

2.7.4 Determination coefficient (r^2) and correlation coefficient (r)

The Determination Coefficient (r^2) reports the models power explanation according to the function of the independent variables considered and it is also one of the efficiency indicators of the regression equation (BAPTISTELLA, 2005).

It is worth mentioning that the determination coefficient doesn’t allow a definitive conclusion about the regression model consistence, that indicates that part of the variation had explanation while the other part can be explained by the absence of other variables or by the market randomness. The correlation coefficient (r) represents the relation between the independent variable with the dependent variable (PELLI NETO, 2006).

According to Baptistella (2005), the correlation coefficient changes between the limits -1 and +1, when this coefficient is zero, meaning that doesn’t exist any relation between the variables, but when it is equal to -1 or +1, means that has a perfect relationship between them. On the other hand, the negative or positive values indicate the direct or indirect relationship between the variables.

2.7.5 Model’s residue

According to Pelli Neto (2003), the residual analyzes is one of the most import definitions of the equation, where some important points must be observed, like: the deviations hope is not null, the model’s deviations are correlated, that the analyzes of the data dispersion graphic around the average is more important to verify if the distribution is homogeneous around the representative straight line;

Another important point to be analyzed it is if the residues show a tendence to a normal distribution, according to the NBR 14653-2 (2011):

- 68% of the data must be between -1 e +1 average pattern deviations;

- 90% of the data must be between -1,64 e +1,64 average pattern deviations;
- 95% of the data must be between -1,96 e +1,96 average pattern deviations.

2.7.6 Homoscedasticity

According to NBR 14653-2 (2011), the homoscedasticity and heteroscedasticity analyzes can be analyzed by the errors disposition, realized by the adjusted values versus the residue's graphic, that can be presented by random points arranged, without the defined patter, therewith it can be said that the errors have constant variance and that the homoscedastic model.

If the points have an ordered distribution, it can be said that there is absence of constant variance and the homoscedastic model, where the regression coefficient are affected by the external values of the variables, because of this the regression equation may be unsuitable.

2.7.7 Collinearity or multicollinearity

According to Mendonça et.al. (1998) multicollinearity is the name given to a general problem that appears from the existence of linear relations between the independent variables, so correlated to each other making it difficult to isolate their separate influences and get an accurate estimate.

The presence of collinearity or multicollinearity makes it difficult to obtain reliable results for the model, but a strong correlation is expected between each independent variable and the dependent variable (PELLI NETO, 2003).

According to NBR 14653-2 (2011), it is necessary to observe the correlations matrix between the independent variables and be alert for results that are superior to 0.80, in order to treat these data in the presence of multicollinearity it is recommended to expand this sample or adopt more refined statistical techniques.

3. Materials and Methods

3.1. Valuetade property choice and characterization

Initially, it was performed an inspection of the property evaluating, where it was possible to extract all the necessary information that was analyzed along with the documentation regarding the property, such as, for example, the total area, built area, its location, finish pattern, and, subsequently, the most important variables were chosen to be used within the appraisal model, in order to obtain a market value for the property in its new state. A photographic report of the asset's use, location and physical characteristics was also made.

3.2. Data Gathering

The necessary data for this study were collected between the months of January and March 2021, in the city of Codó-MA, in real estate agencies, either online or in person, in construction companies that work with the sale of real estate, and in newspaper advertisements. It is worth mentioning that the data provided by the companies were coded in order to maintain confidentiality. The data and variables chosen for the model have important characteristics in determining the value of the property being evaluate.

3.3. Data modeling

The data statistical treatment, in which statistical inference was used, it was performed through the SisDEA software, version 1.50, from the company Pelli Sistemas, which enabled an analysis to choose the most appropriate model for the property typology being evaluated. The use of the SisDEA software allows an improvement on the understanding of the data description by different functions, such as, for example, the application of logarithmic modeling. In comparison with the Excel software, SisDea at the end of the modeling generates a complete statistical report, taking into account aspects provided by NBR 14653-2 (2011), and the Excel does not generate any report.

3.4. Results analyzes

In this step the generated models were analyzed, observing the main characteristics that makes the method and model chosen more effective, following the criteria provided by NBR 14653-2 (2011), in order to use linear regression models and achieving a substantiation degree at least II and accuracy III. Subsequently, the model with all the results was generated. In the physical depreciation analysis, it was used an investigative methodology in order to contribute positively within the evaluation engineering, applying the physical depreciation in a way beyond the usual because of the restrictive measures adopted by the state and federal government to contain the Covid-19 pandemic, making it impossible to survey all the data that make up the sample.

4. Results and discussion

The evaluated property of the study is located at Zota Bayma street, São Sebastião neighborhood, in the city of Codó-MA, approximately 2.4 kilometers away from the influential pole, which would be the downtown, it has a total area of 300m², built area of 116m² and medium residential standards. All roads around the property are pavemented, which facilitates access to the property. Figure 1 shows the property location under evaluation.

Figure 1 - Location of the property being evaluated

Source: Google Maps (2021)

4.1 Statistical report – Multiple linear regression

The independent variables chosen for the model in this study were: total land area (m^2), built area (m^2), and distance to the influential pole (km). The dependent variable is the unitary value. 32 data were collected and only 24 were used in the model, those that were discarded were out of sync with the model, creating many outliers, decreasing the numbers of the determination and correlation coefficient. Table 5 illustrates the variables used, their respective mathematical transformations and significance. Table 6 and 7 show, respectively, some model statistical data and the residuals normality.

Table 4 - Model variables

Variable	**Classification**	**Significance (%)**	**Transformation**
Total Area	Quantitative/Independent	1,85	x^2
Private Area	Quantitative/Independent	0,21	1/x
Distance to the valuation pole	Quantitative/Independent	0,01	x^2
Unit Value	Dependent	0,01	ln(y)

Source: Author's collection (2021)

Table 5 **-** Model Statistics

Model Statistics	**Value**
Correlation coefficient:	0.9078634
Determination coefficient:	0.8242159
Fisher - Snedecor:	31.26
Model Significance (%):	0.01

Source: Author's collection (2021)

Table 6 **-** Normality of residuals

Residue Distribution	**Normal Curve**	**Model**
Residues between -1σ e + 1σ	68%	66%
Residues between -1,64σ e + 1,64σ	90%	95%
Residues between -1,96σ e + 1,96σ	95%	100%

Source**:** Author's collection (2021)

According to Pelli Neto (2003) in order to choose the most appropriate model to be used it is necessary to analyze some criteria and its results, among them: the determination and correlation coefficient analysis, regressors significance analysis, residuals model, among others. For this reason, the model chosen for this study was the most ideal and effective, presenting satisfactory results.

4.1.1 Determination coefficient (r^2) and correlation coefficient (r)

As observed in the Table 5, the determination coefficient was 0.82422159, this means that 82.42% of the values property variation around the arithmetic mean is due to the variable's variation used in the model, the rest of this variation can be explained by other characteristics and variables not studied or by some market randomness. The correlation coefficient was 0.9078, which means that there is a very strong relationship between the independent variables and the dependent variable, as can be seen in the Table 7.

Table 7 - Correlation coefficient ranges

		r	=	0	Null relation
0	<	r	≤	0,3	weak relationship
0,3	<	r	≤	0,7	average relation
0,7	<	r	≤	0,9	strong relation
0,9	<	r	≤	0,99	strongest relation
		r	=	1	perfect relation

Source: Dantas (2003)

4.1.2 Substantiation degree and precision degree

Table 8 presents the substantiation degree score calculation of the report according to the items provided by NBR 14653-2 (2011), and Table 9 presents the result of the score obtained.

Table 8 – Substantiation degree

Item	**Description**	**Degree**			**Points Obtained**
		III	**II**	**I**	
1	Characterization of the property being evaluated	Complete as to all variables analyzed	Complete as to the variables used in the model	Adoption of paradigm situation	3
2	Market minimum amount data, actually used	6 (k+1), where k is the number of independent variables	4 (k+1), where k is the number of independent variables	3 (k+1), where k is the number of independent variables	3
3	Market data identification	Presentation of information regarding all the data and variables analyzed in the modeling, with pictures and characteristics observed by the author's report	Presentation of information regarding all data and variables analyzed in the modeling	Presentation of information regarding the data and variables effectively used in the model	2

4	Extrapolation	Not allowed	Allowed for only one variable, provided that: a) the characteristics measures property being appraised are not superior to 100% of the upper sample limit, nor less than half of the lower sample limit, b) the estimated value does not exceed 15% of the calculated value at the sample boundary for that variable.	Allowed, provided that: (a) the characteristics measurements of the property being appraised are not superior to100 % of the upper sample limit and no less than half of the lower sample limit (b) the estimated value does not exceed 20 % of the calculated value at the sample boundary, for those variables, per si and simultaneously, and in module.	3
5	Maximum significance level (summatory of the two tails) for rejecting the null hypothesis for each regressor (two-tailed test)	10%	20%	30%	3
6	Maximum significance level allowed for the null hypothesis rejection of the model through the Snedecor's F-test	1%	2%	5%	3

Source: Adapted from BRAZILIAN TECHNICAL STANDARDS ASSOCIATION (2011)

Table 9 – Score obtained according to its degree of substantiation

Degrees	III	II	I	Soma
Minimum Points	16	10	6	**17**
Required Items	2, 4, 5 and 6 in grade III and the others at least in grade II	2, 4, 5 and 6 at least at grade II and the others at grade I	All, at least grade I	
Degree of substantiation				**III**

Source: Adapted from BRAZILIAN TECHNICAL STANDARDS ASSOCIATION (2011)

Table 10 presents the dependent variable values, extracted from the SisDEA software, as well as its amplitude, and Table 11 presents the model's framing according to the accuracy degree, according to the items provided by NBR 14653-2 (2011).

Table 10 - Final values of the dependent variable (Unitary value/M²)

	Value (R$/m²)	Amplitude (%)
Minimum	1455,97	5,96
Medium	1548,26	
Maximum	1646,40	6,34
TOTAL		**12,3**

Source: Author's collection (2021)

Table 11 - Framing the model according to degree of accuracy

Description	Degree		
	III	II	I
Confidence interval amplitude of 80% around the central value of the estimate	≤ 30%	30% - 50%	> 50%
Accuracy Degree	**III**		

Source: Adapted from BRAZILIAN TECHNICAL STANDARDS ASSOCIATION (2011)

4.1.3 Projection of value

In order to determine the evaluated property value, its constructed area is multiplied by the average unitary value, the last one indicated by Table 10, obtaining a value of R$ 179,598.16.

Using the rounding provided by NBR 14653-1 (2019), the final value for the evaluated property, taking into account its completely new condition, is R$ 179,600.00.

4.2 Physical depreciation

4.2.1 Asset recovery cost survey

The physical depreciation calculus, in this case, it is in an analytical way, where some pathological manifestations were observed during the evaluated property inspection, and it is intended to make a property cost recovery survey, because of these anomalies, to leave it in like-new condition. Figures 2, 3 and 4 illustrate the main pathological manifestations found.

Figure 2 - Broken ceramic floor

Source: Author's collection (2021)

Figure 3 - Cracks in the sidewalk around the residence

Source: Author's collection (2021)

Figure 4 - Worn-out paint on the building

Source: Author's collection (2021)

In order to achieve the property recovery survey, it was used the SINAPI chart (National Research System of costs and indexes of civil construction) of 03/2021, available from the Caixa Econômica Federal, in order to obtain the cost of inputs and unitary prices, all without tax exemption and, it was adopted a BDI of 27%. Table 12 shows the budget made and the final depreciation value.

Table 12 - Summary budget of the asset recovery survey

Code	**Bank**	**Description**	**Unit**	**Quant.**	**Unit. Value**	**Total**
97633	SINAPI	DEMOLITION OF CERAMIC TILE, MANUALLY, WITHOUT REUSE. AF_12/2017	m²	13	15,60	202,80
87248	SINAPI	CERAMIC FLOOR TILES WITH EXTRA GLAZED SLABS WITH DIMENSIONS 35X35 CM APPLIED IN AREAS LARGER THAN 10 M2. AF_06/2014	m²	13	47,94	623,22
88489	SINAPI	MANUAL APPLICATION OF ACRYLIC LATEX PAINT ON WALLS, TWO COATS. AF_06/2014	m²	142,48	11,61	1.654,19
87692	SINAPI	SCREED IN MORTAR TRACE 1:4 (CEMENT AND SAND), MANUAL PREPARATION, THICKNESS 5.0CM. AF_06/2014	m²	19,32	40,48	782,07
TOTAL BUDGET WITHOUT BDI (R$)						3.263,29
BDI (27%)						881,09
TOTAL BUDGET WITH BDI (R$)						**4.144,37**

Source: Author's collection (2021)

The physical depreciation found by this method was R$ 4,144.37, and the property reissue cost value is the difference between the cost of reproduction, which in this case is R$ 179,600.00, and the value found for physical depreciation. The cost of reissue of the property was R$ 175,455.63.

4.2.2 The consecrated Ross-Heidecke method

According to NBR 14653-2 (2011), the established methods consider the age, building's useful life and state of conservation to calculate the physical depreciation. For the property under evaluation was adopted as effective age 5 years, in the meanwhile the useful life value and residual value was taken into account what is present in Table 1, because it is an average standard house, its useful life was 70 years and residual value of 20%. The building's state of conservation was considered regular, so the Heidecke depreciation coefficient is 2.52%, adopted according to the inspection made on the property being evaluated and taking into account the characteristics present in Chart 2.

This way the coefficient for the effective age regarding the depreciation proportion (Ross), given by Eq.3, is:

$$\alpha = 0{,}038$$

The depreciable value is the difference between the reproduction cost, $179,600.00, and its residual value, 20%, and results in $143,680.00.

That way, the physical depreciation value calculated by the Ross-Heidecke method, given by Eq.1, is:

$$D = R\$\ 8.942{,}99$$

The property rededicating cost, using the depreciation found through the Ross-Heidecke method, was R$170,657.01.

5. Conclusion

Within the Evaluation Engineering there are several methods to estimate the value of a property, however, the guarantor must be aware of certain real estate particularities of the market and the ideal choice of variables that will correspond positively within the evaluation model. The use of statistical inference, within the direct comparative method of market data, is the preferred method of guarantors, because it allows a scientific approach to the property valuation, aiming at a better real estate market interpretation (BAPTISTELLA, 2005).

It was possible to observe in this study that the application of statistical inference and the variables used facilitated the data interpretation and allowed the choice of a model that followed the criteria provided by NBR 14653-2 (2011) and reached substantiation degree III and accuracy degree III.

On the other hand, there are other methods such as cost quantification and evolutionary methods that depend on the application of depreciation coefficients, and in this area, there are differences among guarantors, such as the building's age choice and its state of conservation. These factors can affect the property evaluation, compromising its final value, and there may be differences between the values found by each guarantor, because their choices are based on the free will of each professional.

In this study it was possible to identify this values difference when observing the application of two different methods, presented by NBR 14653-2 (2011), to find the value of physical depreciation. By calculating the property recovery cost survey, the value found of physical depreciation was R$ 4,144.37, but when the established method of Ross-Heidecke was used, which takes into account the age and state of conservation, the value of physical depreciation was R$ 8,942.99, presenting a difference of R$ 4,798.62

Within the area of Evaluation Engineering this difference is small, but it is representative for the budget of a significant portion of the Brazilian population, especially in a period of financial and health crisis. Not only to mention that this difference could be even greater if another guarantor considered a higher property age or a more degrading state of conservation.

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