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Determination of the rental value of a commercial room in the Place Business Center Building located in the city of Manaus - AM

Rugles Fabiam Mendes de Souza Junior[1], Erika Cristina Nogueira Marques Pinheiro[2]

[1] Graduating from the Civil Engineering Course at NiltonLins University, Brazil
Email: ruglesfabianjr@gmail.com
[2] Teacher of the Civil Engineering Course at NiltonLins University, Brazil

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***Keywords*—Evaluation Engineering, Multiple Regression, Commercial rooms.**

Abstract*—*The present work seeks to evaluate the rental value of a commercial room in The Business Center building, in Manaus. In order to meet the proposal, a case study was used as well as a quantitative research. A linear regression model was also used, obtained from a sample of 37 data from commercial rooms collected randomly and identified in a spreadsheet, whose independent variables that formed the value were: private area, basic value, neighborhood, neighborhood income, state of conservation, constructive standard and unit value. The model was analyzed according to the degree of justification, according to NBR 14653-2: 2011, where it met 3 items provided for in the standard, 1 for Grade II (Minimum amount of market data, effectively used) and 2 (Significance level (sum of the value of the two tails) maximum for rejecting the null hypothesis of each regressor (two-tailed test) and Maximum significance level admitted for rejecting the null hypothesis of the model through Snedecor's F test) for attribution of Grade III, this being the higher degree of attribution to a regression model. It is recommended that the database of commercial rooms in the city of Manaus is always updated and that this evaluation methodology is used for other typologies, such as: single-family and multi-family homes, land and the like.

I. INTRODUCTION

The real estate market is an important segment of the economy. It is common practice to assess the importance of real estate to society through its prices. In this context, consumer preferences are basically explained by prices. Properties that offer the most features desired by buyers will be priced higher, and properties with fewer features will be priced lower.

It is important to point out that a relevant characteristic of the market is real estate heterogeneity. This makes it difficult or impossible to directly compare your units and suggests using models to calculate the price. Property valuation is developed with different methods, where the comparative method, based on regression analysis, has been considered an option for allowing good precision and objectivity.

In addition to heterogeneity, there are other elements that differentiate the real estate market from other markets, such as product immobility and the time required for the design and construction of new units. These characteristics impact prices when supply and demand conditions change. When demand increases, prices rise in the short term, because spatial reallocation of supply is impossible and it takes time to deal with increased demand. If demand declines, prices fall, because the owner has to reduce

prices to win back potential customers. On the other hand, location, often cited as the most influential factor in rental prices, also depends on societal preferences. As the product cannot undergo spatial relocation, movements in the environment can improve or worsen the conditions of the property. Consequently, it is easy to see that many attributes must be considered simultaneously in the real estate market analysis, which probably have different values for each situation. In this case, hedonic pricing models gain importance.

Certain basic characteristics can be verified and grouped into three main groups that represent attributes of the construction itself (physical elements), the location and the moment of the transaction. The physical attributes are related to size (total area, number of rooms, bathrooms and garages), construction standard, project, technology and construction method, among others. The location aspects represent the quality and accessibility conditions of the neighborhood. In turn, the neighborhood is related to the presence of public services, level of crime, level of education and income of the people who live in the area. Accessibility refers to the distance or time of access to places that are important to society. Finally, information about the terms of the transaction, such as payment method and time of rental, can also affect prices.

Civil engineers play a crucial role in the pursuit of opportunistic values in the built environment sector. According to Chen (2020), valuation refers to the quantitative process of evaluating the credibility or value of any asset. It requires an adequate technique to determine fair value. When measuring a company's value or value tests capital structure, an analyst is expected to consider potential earnings, the market value of assets, and management.

The initial step in the valuation process is to understand the business interests of the individual, company or organization to accurately perform financial analysis calculations such as growth percentage, P/E ratio, dividends, capital structure, equity, future earnings, etc. . Multiple methodologies and techniques such as the asset approach, the income approach or the market approach are used to estimate the value and prepare the report.

In view of this, the following problem arises: How does Valuation Engineering impact the determination of the rental value of a commercial room in The Place Business Center Building located in the city of MANAUS - AM?

The present work is justified due to the growing demand for real estate transactions in the city, thus awakening the need for a greater adequacy in their evaluations by a qualified professional who can serve different clients and sources to obtain a clear view of the situation, especially in the region, which lacks qualified professionals for this purpose and who can offer adequate services in this area.

The development of this work will allow the creation and development of a team specialized in Assessment Engineering as well as the development of the implementation of routines, database creation and implementation of methods capable of meeting the current and growing demand for assessment work.

Thus, the general objective of this article is to evaluate the rental value of a commercial room in The Business Center building, in Manaus. The specific objectives are: 1) Point out the importance of the Property Valuation to be carried out by an Engineer; 2) Present the specific procedures for rent assessment; 3) Analyze the collected data by applying inferential statistics using the SISDEA software for data modeling as a function of the established variables.

II. LITERATURE REVIEW

2.1 Valuation of rentals

The Manaus real estate market has been growing rapidly since the third quarter of 2020, and this growth has continued throughout 2021. Reports show that the number of properties sold or rented in the region has increased in 2021, making it a highly competitive market. This increase in competition is pushing average rents to higher and higher levels – average rental prices grew between 10% and 20% in 2021 (RIBAS; ALFAIA; RIBAS, 2021).

The Covid-19 crisis also played a role here. The pandemic severely disrupted the market in 2020 as real estate investors and homebuyers delayed their transactions. Alarmed, the government reduced interest rates, with the possibility of extending this movement even further in the future. All of this has contributed to the rapidly changing real estate and rental markets. Thus, a real estate investor needs to make sure that the property is launched to reflect current market conditions (NUNES et al., 2020).

It's nearly impossible to do this without expert insight on your side. Unless you have the knowledge, the tools and – perhaps most importantly – the time it takes to carry out in-depth market research and property valuation. This is where the services of an expert appraiser become invaluable. A regular assessment is a good idea, based on the insight gained from the initial analysis. This is because market conditions can vary significantly from year to year, or even from quarter to quarter (MATOS, 2017).

The rental appraisal process is similar to the appraisal of a property. An appraiser will examine the current

market and the property and recommend a price you can charge for the property. It is also useful in determining whether to hire a property manager or hire a real estate agent to manage investment properties. A good rental appraisal letter also helps to determine the estimated monthly rent. In many cases, you will have a clearer view of how much you can expect to earn from the investment based on the rental market (ANTUNES, 2017)

A rental appraisal will be a valuable tool for landlords. It will show you the potential rentals for the property. It will also include useful information about the local market, including vacancy rates and market trends. Finally, a rental appraisal will detail the types of tenants the property can be rented to. It is essential to remember that a rental appraisal can help you decide the price you can charge for your investment. In this way, you can make an informed decision based on your goals and financial situation (DINIZ, 2011; FAGUNDES, 2014).

During market cycles, ensuring the property remains competitive is vital. This can sometimes mean keeping the rent the same rather than increasing it, or even, with proper advice and consultation, reducing it a little. While this may seem counterintuitive, if the property is not priced competitively with similar properties in the area, it could mean the difference between a rental property and a vacant property. If the market is on a downward trend, the property manager can advise on other ways to keep the property competitive, before the notion of decreasing rent arises (ANTUNES, 2017).

It is important to point out that, in Brazil, there is NBR 14653, which sets the guidelines for the evaluation of assets, regarding: a) classification of their nature; b) institution of terminology, definitions, symbols and abbreviations; c) description of basic activities; d) definition of the basic methodology; e) specification of assessments; f) basic requirements of appraisal reports and technical opinions. This part of NBR 14653 presents guidelines for excellence procedures related to professional practice. This part of NBR 14653 is required in all written technical manifestations related to appraisal engineering activities.

In the meantime, it is pointed out that Resolution nº 218 of CONFEA establishes the professional attributions of the engineer, architect and agronomist in the different modalities and, according to Resolution nº 345 of CONFEA, are the exclusive attribution of engineers in their various specialties, of architects , agronomists, geologists, geographers and meteorologists, registered with the Regional Councils of Engineering, Architecture and Agronomy - CREA, the activities of inspections, expertise, evaluations and arbitrations related to movable and immovable assets, their integral parts and belongings, industrial machines and installations, works and public utility services, natural resources and goods and rights that, in any way, for their existence or use, are attributed to these professions.

2.2 Specific Procedures for Valuing Rentals

In most cases, real estate valuation seeks to obtain a market value (or price at which a property would likely be sold or rented in a normal scenario).

In the usual practice of real estate valuation, there are four methods with which such an estimate is made: COMPARISON, RESIDUAL, COST AND UPDATING. Such methods exist independently of major laws relating to valuation practice.

So, in general, in a market assessment there is no reason to strictly comply with any of these regulations, but rather focus on the philosophy of each of the four methods. In essence, the ultimate goal is to get the market value of the property.

The comparison method is the main one of the four assessment methods, as it is usually present in most assessments. This method is based on the "substitution principle" according to which the value of a property is equivalent to that of other goods with similar characteristics that replace it. Thus, in the real estate valuation field, each asset is unique and singular given its fixed and specific position in space, compared to other valuations where assets do not have this quality. In this sense, the application of homogenization coefficients on the consulted values of the different samples, witnesses or comparables obtained by market studies, is essential to be able to assimilate these values to those of the property to be evaluated (DROUBI et al., 2018).

The residual method is used in the evaluation of soils where the application of the comparison method is not possible due to lack of samples or comparables. Unlike the previous method, the property to be evaluated (vacant land) is not offered to individuals, but to developers. Thus, the method bases its philosophy on considering the value of the land, as the residual value resulting from a real estate development promoted by a hypothetical developer. In this way, the sale value of a vacant lot would result from the subtraction of the necessary associated expenses from the expected sale value of the real estate project. These being from three major groups: construction costs, promotion expenses and promoter benefit. Depending on the time period to be considered, one can speak of two types of residual method. The static residue method, oriented to simulations of approximately less than three years. And the dynamic residual method, oriented to longer periods of time (FREITAS, 2017).

The objective of the cost method is to evaluate the replacement of a property with the current prices of labor and materials. Deducting from this value, the depreciation suffered by the passage of time. Its use refers only to buildings and never to land (RIBEIRO, 2020).

Under the discount method, any asset that produces income, or is intended for some economic activity that generates future periodic income over time, can capitalize or update this value now. The value obtained is the so-called 'rent value' of a property. Said restatement or capitalization is carried out on the net income with interest to be calculated. Net rents are understood to be those from which the expenses necessary to carry out the lease or operation were deducted. On the other hand, the aforementioned interest is obtained by adding to the risk-free interest, the risk rate of use of the associated property (FRONZA, 2018).

ABNT (NBR5676/90) divides assessment methods into two large groups: direct and indirect methods. A method is considered direct when the value of the evaluation result is independent of others. The direct methods are subdivided into the comparative method of market data (defines the value through the comparative observation of values with other similar items on the market) and the comparative method of reproduction cost of improvements (appropriates the value of the improvements). There is a preference for the use of direct methods, and whenever there is sufficient market data for their use, they are chosen (STEINER et al., 2008).

The aforementioned authors also emphasize that a method is considered indirect when it requires results from some direct method. The indirect methods are subdivided into the income method (defines the value in terms of an already existing or expected income for the good on the market, that is, by the economic value of the good); involutive method (the value is estimated by technical-economic feasibility studies of its use) and residual method (calculates the difference between the total value of the property and the value of the improvements, taking into account the commercialization factor).

2.3 Technical Standard for Evaluations

This standard applies to typical market situations. In atypical situations, where the impossibility of using the methodologies provided for in this part of ABNT NBR 14653 is proven, the evaluator may use another procedure, provided that it is duly justified.

NBR 14653 will be made up of the following parts, under the general title “Valuation of assets”: - Part 1: General procedures; - Part 2: Urban real estate; Unauthorized copy Page 3 NBR 14653-1:2001 2 - Part 3: Rural properties; - Part 4: Projects; - Part 5: Machinery, equipment, facilities and goods – Part 6: Natural and environmental resources; - Part 7: Historical Heritage.

The standard establishes the following methods: direct comparative method of market data; evolutionary method; involutive method; and income method.

The Comparative Market Method is currently the most used. It consists of researching market offers and comparing them with the property being evaluated. In this sense, it is necessary that the research has consistency in the similarity of variables that will be worked in the form of Factors or by Statistical Inference. The most used variables are: Built-up area of useful area, parking spaces, finishing standard, location, conservation, among other variables that it deems necessary (GONZÁLEZ, 2010).

The aforementioned author also points out that the Evolutionary Method consists of researching land equivalent to the land of the property to be evaluated and assigning the monthly CUB value to the built area. The CUB will be assigned with the same care as to observe the standard of construction and age of the property (depreciation). This method is most suitable for properties where there is a shortage of compatible offers to compare to the property being evaluated. Examples: Farms, sites, sheds, among others.

The Income Method is little practiced, but common in the Real Estate Market. Basically it consists of the Real Estate Valuation taking into account the income value that will be generated by the property. In other words, the value of the property is determined according to the value that the client can obtain from renting it. This method is little used for residential properties, but one of the most popular Property Valuation methods when it comes to hospitals, universities, schools and other ventures (DANTAS, 2017).

The Involutive Method is the most used Property Valuation Method by Builders and Developers. It consists of pricing the property according to the use of the land. The professional who will analyze the space will take into account all the income that the Construction Company will have with commercial rooms, apartments, kitchenettes, industries, among other examples (DANTAS, 2017).

The first part of the standard is used with another according to the purpose of Real Estate Valuation. It provides an overview of what should be included in a Property Appraisal Report, provides clarifications and definitions.

NBR 14653 defines appraisal engineering as: “A set of specialized technical-scientific knowledge, applied to the appraisal of assets”. According to what Dantas (2017) teaches, evaluation engineering aims to support decision-making regarding cost values and investment alternatives,

involving any type of goods. Also according to the aforementioned author, this specialty is characterized by bringing together a set of knowledge in several areas of knowledge, namely: engineering, architecture, and complementary areas, with the purpose of technically determining the value of an asset, its rights, fruits and costs of reproduction.

Item 3.19 of the standard addresses the evaluation engineer and asserts that he must be a professional with a higher level, with legal qualifications and technical-scientific training to carry out evaluations, duly registered with the Regional Council of Engineering, Architecture and Agronomy - CREA.

III. METHODOLOGY

The present study was characterized as a research with a mixed approach, with a concomitant triangulation strategy.

Thus, it is qualitative, because it aims to clarify the complexity of the problem based on conceptual studies, and quantitative, because values were measured, both in the assembly of the data to be evaluated, and in the attribution of value to dichotomous variables.

This research was conducted through bibliographic, documentary and case study research.

The information that served as the basis for this study was extracted through several steps to the company's database, especially concerning the Building The Place Business Center, taking the following devices as guidelines: document analysis; examination of records; correlation between the information obtained and analytical review.

To achieve the proposed objectives, the following steps were developed:

a) Documentary research, through bibliographic consultation of normative documents of periodicals on the proposed theme, in addition to consultation through the internet;

b) Analysis of the information collected in order to identify the problem involved and looking for solutions and conclusions for the deficiencies contacted;

c) Research in the institution's field of activity, with the identification and study of the case found.

Figure 1 presents the flowchart of the methodology adopted in the present work.

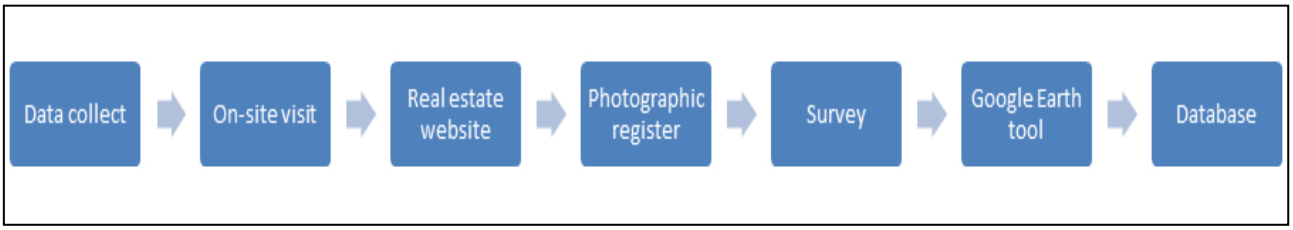

Fig. 1: Figure Title below the figure

With this information, it was possible to build the results of the present work.

IV. RESULTS AND DISCUSSION

First, a database about commercial rooms was created to glimpse some aspects such as area, parking spaces, closets, among others, as shown in Table 1.

Table 1: Result of the case study statistical inference calculation

Residential	Neighborhood	Area	vacancies	Cabinets	Walk	Main road	Value of neighborhoods	Income	Conservation state	Standard	Unit price	Price
Brittania Park Offices	Ponta Negra	32,00	1,00	1,00	9,00	3,00	384,05	12.895,09	2,00	4,00	75,00	2.400,00
Sky Platinum	Chapada	30,00	1,00	1,00	18,00	3,00	331,68	6.173,36	5,00	5,00	126,67	3.800,00
Millenium	Chapada	30,00	2,00	1,00	10,00	3,00	1.973,85	6.173,36	5,00	5,00	100,00	3.000,00
Brittania Park Offices	Ponta Negra	32,00	1,00	2,00	4,00	3,00	572,81	12.895,09	4,00	4,00	109,38	3.500,00
Ed. Atlantic Tower	Chapada	32,00	2,00	1,00	15,00	3,00	1.973,85	6.173,36	4,00	3,00	78,13	2.500,00

Ed. Cidade de Manaus	Centro	23,00	1,00	1,00	3,00	3,00	492,36	3.822,18	4,00	2,00	32,39	745,00
Millenium	Chapada	32,00	2,00	1,00	18,00	3,00	1.973,85	6.173,36	3,00	4,00	78,13	2.500,00
Ed. Empire Center	Chapada	35,00	2,00	1,00	6,00	3,00	546,75	6.173,36	3,00	4,00	51,43	1.800,00
Amazon Trade Center	Adrianópolis	32,00	2,00	1,00	8,00	1,00	179,69	9.083,18	4,00	4,00	78,13	2.500,00
SoberaneCoorporate	Adrianópolis	35,00	2,00	2,00	9,00	2,00	481,53	9.083,18	5,00	5,00	114,29	4.000,00
SoberaneCoorporate	Adrianópolis	35,00	2,00	2,00	10,00	2,00	481,53	9.083,18	5,00	6,00	137,14	4.800,00
Atrium	São Francisco	38,00	2,00	2,00	3,00	1,00	179,69	2.673,73	3,00	3,00	47,37	1.800,00
The Place Business	Adrianópolis	34,00	2,00	1,00	7,00	2,00	481,53	9.083,18	4,00	4,00	72,06	2.450,00
The Place Business	Adrianópolis	41,00	2,00	2,00	11,00	2,00	481,53	9.083,18	4,00	4,00	73,17	3.000,00
The Place Business	Adrianópolis	36,00	2,00	1,00	10,00	2,00	481,53	9.083,18	5,00	4,00	111,11	4.000,00
The Place Business	Adrianópolis	31,00	2,00	1,00	2,00	2,00	481,53	9.083,18	5,00	4,00	83,87	2.600,00
Atlântic Tower	Chapada	33,00	2,00	1,00	7,00	3,00	1.973,85	6.173,36	4,00	4,00	106,06	3.500,00
SoberaneCoorporate	Adrianópolis	35,00	2,00	1,00	5,00	2,00	481,53	9.083,18	5,00	6,00	128,57	4.500,00
Vieiralves Business	Adrianópolis	32,00	2,00	1,00	2,00	1,00	481,53	9.083,18	4,00	3,00	78,13	2.500,00
Amazon Trade Center	São Francisco	32,00	2,00	2,00	11,00	1,00	179,69	2.673,73	4,00	3,00	78,13	2.500,00
The Office	Adrianópolis	41,00	2,00	1,00	8,00	2,00	481,53	9.083,18	4,00	4,00	97,56	4.000,00
Cemom	Nossa Sra. Das Graças	36,00	2,00	2,00	3,00	1,00	481,53	7.246,36	3,00	2,00	55,56	2.000,00
Forúm Business	Adrianópolis	30,00	2,00	1,00	9,00	3,00	481,53	9.083,18	4,00	4,00	73,33	2.200,00
Atlântic Tower	Chapada	33,00	2,00	2,00	3,00	3,00	1.973,85	6.173,36	4,00	4,00	87,88	2.900,00
Mundi	Aleixo	36,00	1,00	2,00	7,00	3,00	412,36	7.450,53	4,00	3,00	91,06	3.278,00
Sky Platinum	Chapada	32,00	1,00	2,00	10,00	3,00	331,68	6.173,36	4,00	4,00	78,13	2.500,00
Forúm Business	Adrianópolis	41,00	2,00	1,00	5,00	3,00	481,53	9.083,18	4,00	3,00	65,85	2.700,00
Sky Platinum	Chapada	48,00	2,00	2,00	8,00	3,00	331,68	6.173,36	4,00	4,00	80,00	3.840,00
Cristal Tower	Adrianópolis	45,00	2,00	1,00	7,00	3,00	1.211,53	9.083,18	4,00	5,00	144,44	6.500,00
SoberaneCoorporate	Adrianópolis	35,00	2,00	1,00	2,00	2,00	481,53	9.083,18	2,00	3,00	100,00	3.500,00
Amazon Trade Center	São Francisco	32,00	2,00	1,00	7,00	1,00	179,69	2.673,73	4,00	4,00	71,88	2.300,00
Millenium	Chapada	35,00	2,00	1,00	11,00	3,00	1.973,85	6.173,36	4,00	4,00	85,71	3.000,00
The Place Business	Adrianópolis	32,00	2,00	1,00	2,00	2,00	481,53	9.083,18	3,00	3,00	71,88	2.300,00
The Place Business	Adrianópolis	32,00	2,00	2,00	8,00	2,00	481,53	9.083,18	5,00	5,00	118,75	3.800,00
The Place Business	Adrianópolis	36,00	2,00	2,00	3,00	2,00	481,53	9.083,18	4,00	4,00	97,22	3.500,00
Sky Platinum	Chapada	26,00	2,00	2,00	9,00	3,00	331,68	6.173,36	4,00	4,00	107,69	2.800,00
Sky Platinum	Chapada	40,00	2,00	2,00	7,00	3,00	331,68	6.173,36	4,00	3,00	87,50	3.500,00

Firstly, as described in the methodology, a Case Study was used, which used the 1st data model – 32 data. It is important to note that the variables were disabled

In terms of Walking, the significance was inverted (the bigger the more expensive and in the first model, the bigger the cheaper);

In relation to the road, it did not work, since practically all the projects are inserted in an urban corridor, that is, those that were placed 2 or 1 are in the zone of influence of urban corridors - Ex: CEMOM was initially classified as 1 (collector), however, it is considered the main neighborhood, as it is 600 meters from an urban corridor (Djalma Batista) inserted in Vieiralves. In this way, as determined by the Manaus master plan, it is influenced by this zone and has guarantees as if they were inserted in this corridor, in the stretch of the master plan it informs border strips up to 300 meters from the urban corridor, but in practice there is the influence of this corridor , as shown in Figure 2.

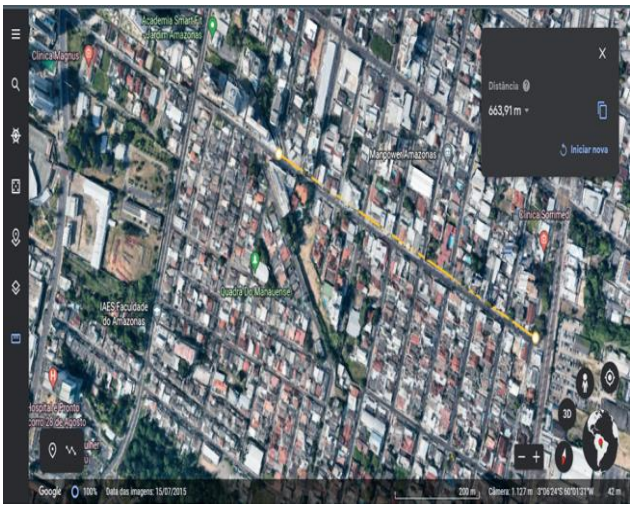

Fig. 2: Case study location

In relation to parking spaces, this variable was not used either, since it did not present variance, that is, practically all projects have a rotating parking space, and in the model this information was clear because it presented high correlation;

As for the Closet Variable, it was not possible to use it initially, as there was no identification through the search site, where the advertisers did not present photos that showed that there would be closets at the place to be inserted in the lease of 10 rooms, however, after the request for information with the advertisers, the cabinets variable was tested again, where the model did not adhere to the specifications to keep it cohesive; Amplitude (Ok).

The calculation of the statistical inference was performed (Figures 3 and 4), where it was possible to verify that some points were not adjusted as the Determination, the closer to 100% the better, and in this first model the mean of the regression and estimate is 70% , in addition, the final value of the rent was above the average of the data collected in the same enterprise.

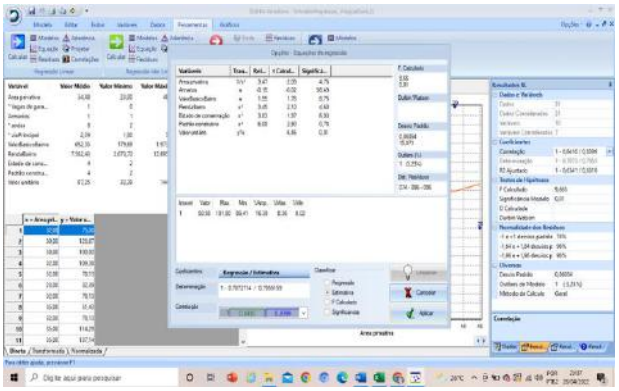

Fig. 3: Result of the case study statistical inference calculation

Fig. 4: Result of the case study statistical inference calculation

In this case, it was necessary to analyze the database surveyed, where it was concluded that it would be necessary to include more data in the model, especially in the model to improve the sampling and reach a degree of reasoning as close to III, as shown in Table 1, in the NBR 14653-2.

Table 2: Degrees of reasoning in the case of using linear regression models

Item	Description	Degree		
		III	II	I
1	Characterization of the property being evaluated	Complete regarding all analyzed variables	Complete regarding the variables used in the model	Adoption of a paradigm situation
2	Market data collection	Characteristics conferred by the author of the report	Characteristics conferred by a professional accredited by the author of the report	Features provided by third parties may be used
3	Minimum amount of market 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
4	Identification of market data	Presentation of information related to all data and variables analyzed in the modeling, with photo	Presentation of information regarding the data and variables actually used in the model	Presentation of information regarding the data and variables actually used in the model
5	Extrapolation	not admitted	Admitted for only one variable, provided that: a) the measurements of the characteristics of the property being evaluated are not greater than 100% of the upper sample limit, nor less than half of the lower sample limit b) the estimated value does not exceed 10% of the value calculated in the limit of the sample boundary, for the aforementioned variable	Admitted, provided that: a) the measurements of the characteristics of the property being evaluated are not greater than 100% of the upper sample limit, nor less than half of the lower sample limit b) the estimated value does not exceed 10% of the value calculated at the limit of the sample boundary, for the aforementioned variables, simultaneously
6	Significance level □ (sum of the value of the two tails) maximum for rejecting the null hypothesis of each regressor (two-tailed test)	10%	20%	30%
7	Maximum significance level allowed in the other statistical tests performed	1%	5%	10%

In order to increase the reliability of the sample, it was necessary to increase the data collected, from 32 to 37 data, being used 32, and mixing the use of previous and new data, results were obtained within those foreseen in the standard.

With the theoretical domain and Microsoft Office Excel tools, the sample was analyzed in SisDEA Home software, a data modeling program withsupport for comparative evaluations of the real estate market. With this feature,enabled numerous combinations of variables influencing value,based on statistical inference, where the model that best explain the behavior for the present case study.

Commercial Offices available for lease in 2022 were used as a Model, with reference to April 22, 2022. Table 3 presents some Complementary Information:

Table 3: Additional information

Model variables and data	Quantities
Total variables	10
Variables used in the model	6
Total data	37
Data used in the model	32

It is important to point out that there are 10 variables, however, for the present study, only 6 were used (private area, basic neighborhood value, neighborhood income, state of conservation, constructive standard and unit value.

Table 4 highlights the statistical data of the case study, and it is possible to point out Correlation coefficient, Determination coefficient, Fisher – Snedecor and Model significance (%).

Table 4: Case study statistics

Model statistics	Value
Correlation coefficient	0,9048430 / 0,9075667
Determination coefficient	0,8187409
Fisher - Snedecor	23,49
Model significance (%)	0,01

To analyze the degree of dependence between the dependent variables and independent in the regression model, according to Ramos (2013) the use of thecorrelation coefficient, where the result can vary between -1 and +1, the variable withhighest dependency should be as close to 1, and the one with lowest dependencywill have its value closest to 0.

According to Silva (2016) the coefficient of determination indicates in percentage the explanation of this model, that is, it measures the degree of fit of the regression equation.

Table 5 shows the normality of the residues.

Table 5: Normality of waste

Distribution of waste	Normal Curve	Model
Waste located between -1 σ e + 1σ	68%	75%
Waste located between -1,64 σ e + 1,64 σ	90%	90%
Waste located between -1,96 σ e + 1,96 σ	95%	100%

In verifying the distribution of waste, according to Table 5, it was found that in the range [-1.64; +1.64] the value obtained in the model is exactly equal to the theoretical value. In relation to the range -1σ and + 1σ, the value was slightly higher, with a difference of 7%. In the interval 1.96 σ and + 1.96 σ the difference was 5% of the normal curve for the model.

Regarding the outliers of the regression model, they were not detected in the model under study.

Table 6 highlights the results of the analysis of variance from the case study.

Table 6: Analysis of variance

Source of variation	Sum of squares	Degrees of Freedom	Square Medium	F
Explained	42,084	5	8,417	23,488
Not explained	9,317	26	0,358	
Total	51,401	31		

The calculated F value for a significance of 1% was 23,488.

Below is the regression equation / estimation function (mode, median and mean):

Unit value ½ = +5.236837565 -1347.386557 / Private area² +2.198929688E-007 * BasicValueNeighborhood² +1.16367901E-008 * Neighborhood income² +0.7643987514 * State of conservation +0.06795452947 * Constructive standard²

Figure 4 illustrates the Adherence Graph - Linear Regression of the case study.

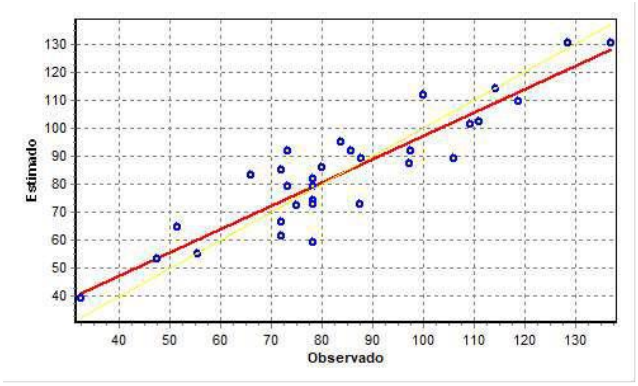

Fig. 4: Adherence Graph - Linear Regression

The adherence of the model can be verified through visualization graph in which observed values versus predicted values are plotted. And the closer the points are to the reference line, the greater the fit of the model to the data.

In figure 5 it is possible to observe the results of the evaluation through the residual graph.

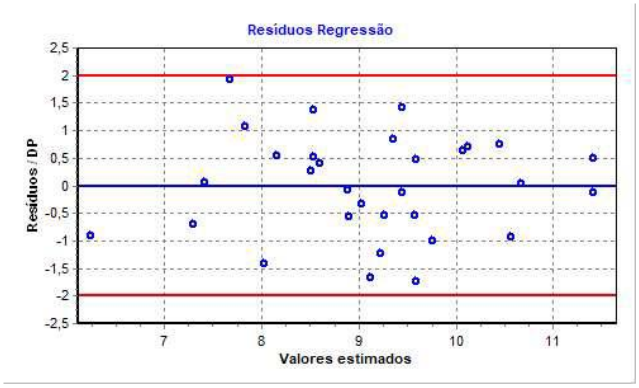

Fig. 5: Residual plot - Linear Regression

According to Levine (2014), the residual graph serves as a strategy for checking the assumptions for regression (linearity, independence, normality, homoscedasticity)

V. CONCLUSION

detailed scientific analysis of the real estate market in the city of Manaus is very important, especially due to the results obtained, for this linear regression was developed through a traditional approach, in search of transforming the existing conditions, in order to confirm of the 06 hypotheses of the model.

The general objective, which was to evaluate the rental value of a commercial room in The Business Center building, was achieved with the application of linear regression. The database that made it possible to generate the model was composed of 37 data from commercial rooms collected, and 06 independent variables were taken into account: private area, basic neighborhood value, neighborhood income, state of conservation, construction standard and unit value.

The model was analyzed according to the degree of justification, according to NBR 14653-2: 2011, where it met 3 items provided for in the standard, 1 for Grade II (Minimum amount of market data, effectively used) and 2 (Level of significance (sum of the value of the two tails) for the rejection of the null hypothesis of each regressor (two-tailed test) and Maximum level of significance allowed for the rejection of the null hypothesis of the model through of Snedecor's F test) for Grade III attribution, this being the highest attribution degree for a regression model.

It is recommended that the database of commercial rooms in the city of Manaus is always updated and that this evaluation methodology is used for other typologies, such as: single-family and multi-family homes, land and the like.

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