Budgeting of Civil Construction Works in Brazil: Linear Correlation Assigned to the Market Cost and the Reference Cost

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***Abstract*-- This article proposes a reflection on the type of methodology and statistical treatment to be used in research on costs, for inputs used in civil construction, aiming to define a remuneration increasingly compatible with the charges assumed by Brazilian bidders. The objective is to identify, through the Pearson linear correlation coefficient, which reference system, among the three used for budgeting works of civil construction, has the lowest margin of overpricing and/or underpricing in relation to the cost effectively traded in the market. The Costs Bulletin System (SBC Informative) presented the main results, 0.9766 and 0.9808, respectively, for material and labor inputs, with a confidence level equal to 99%.**

***Index Term* -- Wholesale and Retail Trade, Civil Construction, Linear Correlation, Market Cost, Quotation Effect, SINAPI.**

I. Introduction

In Brazil, the reference cost of engineering works and services, considered as civil construction services, funded by the federal government, must be obtained from unit costs that are lower than or equal to the median of their counterparts in the reference unit costs available in the catalog of the National System of Survey of Costs and Indexes of Civil Construction - SINAPI. In the case of impracticability regarding the definition of costs from SINAPI, i.e., when the services to be budgeted are not contemplated in its catalog, it can be used the data contained in a reference system formally approved by bodies or entities of the Federal Government, in specialized technical publications, in a specific system established for the sector (sanitation, housing, etc.) or in market research [5].

Containing at least three quotations from different suppliers [8], the quotation of costs must be performed in wholesale markets, retail shops or next to their manufacturers, according to the desired amount [7]. The result of the market research is the average or the lowest cost from those obtained [6].

According to Leitão [13], there are often allegations coming from contractors during the execution of public works contracts, stating that the constant costs in SINAPI do not reflect the reality of the market, and that they are lower than the costs charged by the trade, even some public officials have this understanding.

In this context, would the public works contractors be bound to get impaired because of distortions caused by the costs arising from the reference systems? Apparently not always, as stands out in the following statement:

> "The request for contractual amendments by contractors is very common in public works in Brazil, sometimes arising from relevant changes in projects during the execution of the work and/or in supervening events that will increase the work cost for companies. Notwithstanding, what is seen, in most cases, are proposals for amendments to the projects (and technical specifications) in order to get out of the bid (disputed) items and include new items in the contract, with prices above market benchmarks or, at least, without the discount granted in the respective bidding process." [13].

The general problem mentioned by Leitão, when particularized, can lead to the occurrence of a very specific trick, the election of companies aiming to substantially change the technical specifications of the engineering designs, without a plausible explanation from the technical point of view or without adding value to the contractual object, this being the work itself, as the final product.

According to Baeta [1], the adoption of solutions technically inferior to those originally contracted can result in the disfigurement of the bid object, with deletions and/or additions of original bidding services, and with the inclusion of new services in the budget.

The contractual amendment may be suggested by the contractors as a subterfuge to gain profit or reduce damage only. Aiming to increase the quantities of an already disputed service or the inclusion in the contractual budget of a new service item, with the cost charged in the near local market or below that cataloged in SINAPI or in another system. Excluding, depending on each case, a service item already bid, with the cost cataloged in SINAPI, or in another system, lower than that practiced in the local market.

Given the above, this paper aims to point out to which reference system, of three, the attribution of unit costs derived from market research has the lowest dispersion and the highest coefficients of linear correlation and determination, individually, for material and labor inputs of civil construction. SINAPI, in addition to a source belonging to the municipal level, the Construction Costs System (SCO/RJ) and a source coming from a private institution (SBC Informative) are part of the study.

II. Theory

A. Literature Review in the Light of the State of the Art

According to Brasil [7], beyond SINAPI, there are examples of reference cost systems, some aimed at a sector in

particular, held by agencies or federal, state and municipal entities such as:

- DNOCS – National Department of Works Against Drought;
- CODEVASF – Development Company of the São Francisco and Parnaíba Valleys;
- SCO - Construction Costs System (Municipality of Rio de Janeiro);
- EMOP – Company of Public Works in the State of Rio de Janeiro;
- Municipal Secretary for Urban Infrastructure and Construction - SP Prefecture;
- SEINFRA – Infrastructure Secretary (State of Ceará);
- SETOP – State Secretary for Transport and Public Works of Minas Gerais;
- ORSE – Sergipe Works Budget developed by the State Company for Housing and Public Works of Sergipe - CEHOP;
- SANEPAR – Sanitation Company of Paraná;
- CAESB – Environmental Sanitation Company of the Federal District;
- COPASA – Sanitation Company of Minas Gerais;
- EMBASA – Bahian Company of Water and Sanitation;
- DERSA – Highway Development S/A (State of São Paulo).

According to Bernardes et al. [2], there is the lack of studies on the production costs of engineering activities and services. Since the practice of Cost Engineering with appropriate methodology from specialized publications or reference systems like SINAPI is still quite limited, especially in the segment of medium and small enterprises, which has entered an adventure bias to this business activity. Thus, these companies are often subject to prices established by public contractors, which are not even sufficient to remunerate services. Not to mention the risky practice of offering discounts beyond what would be reasonable for such reference prices, which intensifies the adventurous mentality of bidders.

The SINAPI cost compositions (synthetic and analytical) have many misconceptions to be solved, because, in theory, they are meant to the construction of buildings of the Caixa Econômica Federal - CEF. So, they have no use for other segments of civil construction, thanks to the limitations that are imposed by the defects which it contains [17]. For example, there is the lack of information on services performed in large building works presenting modern constructive elements, like dry wall panels, high performance prestressed or designed concrete, ribbed alveolar and steel deck slabs, glass skin, root cuttings, etc. [1].

If the supply and installation of a particular special lock is indicated in the specification of a work, it is necessary to make the substitution, in the corresponding unit cost analytical composition (detailed inputs), of the cost of the standard lock determined by SINAPI by the cost of the specified one, obtained through market research [15]. Nevertheless, to the extent that every budget is unique, its properties (specificity, temporality, approach and adherence to the contract) require adjustments in the productivity and consumption rates present in the standard analytical compositions of SINAPI, to adapt them to the reality of the work that is being budgeted [7].

According to Brasil [3], some of the main products generated by SINAPI and constantly updated are:

- Reports of Inputs, costs with exoneration (without social security contributions) and without exoneration (with social security contributions), for each Federation Unit;
- Reports of Synthetic Compositions (without detailing of inputs), costs with and without exoneration, for each Federation Unit;
- Analytical Compositions Catalogs;
- Technical Notebooks of measured compositions available in Public Consultation;
- Report of Inputs Maintenance - National Bank;
- Report of Altered Compositions;
- Spreadsheets of Social Charges, with and without exoneration, for each Federation Unit;
- Manual of Methodologies and Concepts of SINAPI.

In SINAPI, the inputs, whether relating to the material or labor, are structured in homogeneous families (e.g. PVC pipes for building sewage), to which the higher recurrence input is selected (e.g. 9836 - PVC TUBE NORMAL SERIES - BUILDING SEWAGE DN 100 MM - NBR 5688) as a representative input, and the others of its family are called represented inputs. Representative inputs have their costs collected monthly by the Brazilian Institute of Geography and Statistics - IBGE, while the other inputs have their costs obtained through the use of representative coefficients, which indicate the proportion between the costs of the family leaders (representative inputs) and the costs of each of the other family inputs [3].

After defining the sample, carried out by IBGE, with the effective quotation of the unit values for representative inputs, only three results are disclosed for each. By performing the statistical processing of the data: 1st quartile, median and 3rd quartile. The unit cost of the 1st quartile is that superior to 25% of all unit values listed, while the 3rd quartile is superior to 75%. Therefore, the median of SINAPI, by definition, is the central unit cost obtained in the survey [11].

According to the research conducted by Dantas [10] in the city of Brasília-DF for the construction of public housing units, budgeted from the costs of the constant inputs of SINAPI, it was observed an overpricing (high prices) in the order of 6.55% in relation to the median of the labor inputs, Table 1. In addition, for material inputs, it was observed an overpricing in the order of 1.7% in relation to the median, and an underpricing (reduced prices) in the order of 6.5% compared to the 1st quartile, as seen in Table 2. The methodology used was the selection of inputs through the development of ABC curve, from the budgets available on the CEF website for housing units, and subsequent market research for material inputs in shops of Brasília. As for the search of labor inputs, the reference values were taken from the collective labor agreement of the Union of Workers in Building and Furniture Industries of Brasilia - STICMB, using the same percentage of Social Charges adopted by SINAPI, of 124.20%, on the cost for the worked hour.

TABLE I
Wage Floor of Professional Categories [10]

ITEM SINAPI Code	Worked Hour STICMB	Social Charges (124.20%)	Reference Value	SINAPI Value	Quantity	Total Reference	Total SINAPI
6111	R$ 2.28	R$ 2.83	R$ 5.11	R$ 5.50	691.03	R$ 3,532.38	R$ 3,800.67
4750	R$ 3.54	R$ 4.40	R$ 7.94	R$ 8.50	372.51	R$ 2,956.49	R$ 3,166.34
4783	R$ 3.54	R$ 4.40	R$ 7.94	R$ 8.50	534.89	R$ 4,245.25	R$ 4,546.57
1213	R$ 3.54	R$ 4.40	R$ 7.94	R$ 8.50	415.88	R$ 3,300.71	R$ 3,534.98
6117	R$ 2.56	R$ 3.18	R$ 5.74	R$ 6.07	345.51	R$ 1,983.06	R$ 2,097.25
6115	R$ 2.28	R$ 2.83	R$ 5.11	R$ 5.50	315.84	R$ 1,614.50	R$ 1,737.12
2696	R$ 3.54	R$ 4.40	R$ 7.94	R$ 8.50	171.25	R$ 1,359.16	R$ 1,455.63
242	R$ 2.56	R$ 3.18	R$ 5.74	R$ 6.10	216.39	R$ 1,241.97	R$ 1,319.98
2436	R$ 3.54	R$ 4.40	R$ 7.94	R$ 8.50	109.96	R$ 872.72	R$ 934.66
6130	R$ 2.56	R$ 3.18	R$ 5.74	R$ 6.07	116.36	R$ 667.85	R$ 706.31
TOTAL						R$ 21,774.09	R$ 23,299.48

TABLE II
Material Inputs Cost [10]

ITEM SINAPI Code	Quantity	1st Quartile		Median	
		Quotation	SINAPI	Quotation	SINAPI
1379	16,803.58	R$ 5,713.22	R$ 5,881.25	R$ 5,830.84	R$ 6,217.32
7271	9,590.71	R$ 5,083.08	R$ 3,847.79	R$ 5,274.89	R$ 5,083.08
11088	5,106.84	R$ 2,872.60	R$ 2,757.70	R$ 2,987.50	R$ 3,013.04
370	36.09	R$ 2,562.42	R$ 2,149.18	R$ 2,598.51	R$ 2,344.79
11197	10.22	R$ 1,686.67	R$ 1,715.19	R$ 1,686.67	R$ 2,223.54
367	30.25	R$ 2,147.46	R$ 1,843.49	R$ 2,177.71	R$ 2,011.35
1289	93.02	R$ 827.91	R$ 1,378.62	R$ 827.91	R$ 2,007.46
1106	4,036.73	R$ 1,562.72	R$ 1,614.69	R$ 1,664.14	R$ 1,655.06
4718	26.03	R$ 1,451.37	R$ 1,562.02	R$ 1,633.61	R$ 1,567.22
651	1,000.43	R$ 2,305.98	R$ 1,380.59	R$ 2,651.13	R$ 1,380.59
11155	8.47	R$ 1,346.53	R$ 925.38	R$ 1,524.38	R$ 1,138.20
7344	29.75	R$ 580.18	R$ 991.36	R$ 595.06	R$ 1,100.85
27	170.74	R$ 594.88	R$ 630.03	R$ 693.84	R$ 759.80
37	138.21	R$ 407.03	R$ 597.05	R$ 531.74	R$ 720.06
5061	82.42	R$ 494.50	R$ 510.98	R$ 535.70	R$ 540.65
7258	2,159.79	R$ 453.56	R$ 455.28	R$ 539.95	R$ 539.95
TOTAL VALUES		R$ 30,090.11	R$ 28,240.60	R$ 31,753.58	R$ 32,302.96

B. Distortions between actual costs and the constant costs of SINAPI

As a rule, it is known that purchases made in large volumes can get significant discounts compared to the cost that the consumer pays to make the purchase of small quantities of the same product. In civil construction, such discounts, obtained by scale gains, tend to be small for basic materials (cement, steel) and more expressive when it comes to finishing materials [15]. Besides the natural market fluctuation between suppliers, the distortions relating to the costs effectively traded in the market and the constant costs in SINAPI can be attributed to the following phenomena:

> "a) **Quotation Effect:** result of the routine procedure of price survey, through which the buyer performs quotations and chooses the establishment that had the **lowest price**, turning the price actually paid by the manufacturer **below the median** of the consultations carried out by him.
> b) **Bargain Effect:** result of the negotiation of large amount, which causes **reduction in the unit price** of the material to be bought in function of the scale economies.

c) **Brand Effect:** result of the price collection of inputs supposedly with the same specification, but with different brands. This effect **can distort the reference price to more or less**, depending on the relationship between the quoted input and the one that should be effectively referenced. It can also bring about effects on the compositions of services, since certain better quality brands have superior performance compared to others, though all are within the same level of technical specification.

d) **Public Administration Effect:** comes from the identification, by the buyer, that the acquisition will meet the public agency. In the case of **quotations**, this effect **tends to cause an increase in prices** reported by the supplier, due to two main factors. The first is that there is no expectation of immediate purchase or competition between suppliers, causing the seller to provide **counter price**, without offering any rebate commonly offered, as he regards the research as mere information and not as a potential sale. The second important factor is that, in general, the quotations performed by the Public Administration are intended to subsidize a base budget for bidding, leading suppliers to include a

larger margin on the price charged, so that they are still able to **reduce the price in the competitive bidding environment**. Much of the alleged savings observed in biddings undertaken by public administration, especially in cases where the percentage difference between the budgeted and contracted values is significant, are due to the distortions caused by this effect at the time of cost estimate.

e) **Package Effect:** caused by inadequate choice of sales unit for the type of input researched, in view of the most usual form of marketing, its purpose and application. **It may cause distortion of prices to more or less**: if the consultation considers larger packages than those usually used, **the relative price tends to be lower**; if it considers smaller packages, **it tends to be higher**. It is noteworthy that this effect is not confused with the bargain effect, which relates to the sales volume. In the present case, the differentiating factor is the actual product packaging, regardless of the number of units to be acquired.

f) **Correlation Effect:** result of the disproportionate variation in prices of inputs represented in the time interval between the completion of extensive collections. It follows the discrepancy of the coefficient applied to the price of the representative input to obtain the price of the represented input, and is linked to the methodology adopted by the IBGE in the operationalization of the collection. **It may cause distortions to more or less**.

g) **Imputation Effect:** resulting from the application of prices from several establishments in the composition of the median of a given location, without taking into account the costs of the input transport. In general, this effect **tends to distort downwards the reference price**, since the price in a location different than the originally considered should be added to the transportation cost to the destination location. However, **it may also distort the price upwards** if the FU used has higher prices than those actually charged on the local market.

h) **Specification Divergences:** in addition to the effects mentioned above, **there are plenty of distortions** caused by divergences between the specification of the product collected by IBGE and that of the input whose price is referenced in SINAPI. That is, the IBGE collects the price of a product with a particular specification, but its input in SINAPI presents a different specification." [9] (emphasis added).

According to research conducted by Filho, Lima and Maciel [11] for large works in the city of Brasília - DF, whose overall cost exceeds four million reais in the case of infrastructure and paving, and ten million reais in the case of buildings, the sum of the distortions provided by the Quotation and Bargain Effects for the purchase of inputs and materials result in savings of about 15% on the overall cost of works budgeted from the median of SINAPI. The result of the study was obtained through extensive real market research and statistical processing of the data collected from official sources. In addition to the SINAPI itself, it were used the minutes of the sessions (bidding mode) available in the shopping portal of the federal government (Comprasnet), in the shopping portal of the Federal District (e-ComprasDF) and in the invoices obtained. For the case of Quotation Effect, Figure 1 shows the cumulative values of purchases as a function of the discount or increase over the SINAPI, showing that 45.4% of the funds would be invested in purchases by a price less than or equal to the 1st quartile, and 68.7% in those with price equal to or lower than the median.

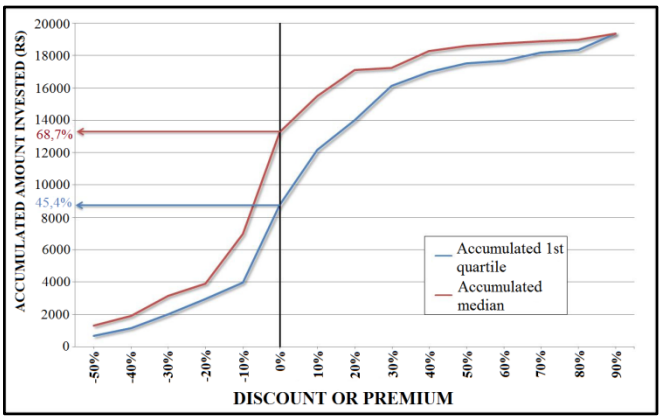

Fig. 1. Value applied as a function of the discount or increase over the SINAPI [11]

The saving in the order of 15% on the overall cost of works, budgeted from the median of SINAPI, can be one of the funding sources of criminal organizations. Given that the Federal Police of Brazil has demonstrated the existence of corruption, collusion and bribery even in construction bids that were contracted and implemented with a price consistent with the official sources of reference. This is a veiled form of overbilling (billing with a price higher than that of the market), which will not be identified by control bodies while the median of SINAPI remains the main yardstick of their analysis [11].

It is noteworthy that the 1st quartile of SINAPI may not adequately represent the Quotation Effect in virtue of the prevailing differences related to the brand, price and quality in some types of material inputs. Thus, products with lower quality and price will probably be in the 1st quartile, in return, the products with higher quality and price will be in the 3rd quartile of the prices surveyed [1].

III. Methodology Employed in the Experimental Search

The sample, object of study of the research, was quantified by identifying the material and labor inputs, respectively, with similar category and technical specification, present in the catalogs of the three sources of costs (continuous dependent variables) used in the experiment.

Based on the sample characteristics, the market research (continuous independent variable) consists of at least three quotations from the distinct and active suppliers of the market in the state of Rio de Janeiro, the data were provided by the company Índice, Planejamento, Controle, Orçamento e Gestão Ltda. (Index, Planning, Control, Budget and Management Ltd.), headquartered in the city of Niterói - RJ, and active in

the field of Cost Engineering for real estate projects in the following areas: Metropolitan region; Lakes region and north of the state of Rio de Janeiro.

The maximum and minimum value were adopted as statistical treatment for the data, the first has as parameter the highest wage floor by category to labor inputs, and the second, the reproduction of the Quotation Effect for material inputs.

IV. Linear Correlation Assigned to the Market Cost and the Reference Cost

The sample used in the experiment contains 59 material inputs and 28 labor inputs, extracted from the catalogs of SINAPI, SCO/RJ and SBC Informative - Costs Bulletin System. The classification of the inputs that make the sample are detailed, as seen in Figures 2, 3, 4 and 5 below:

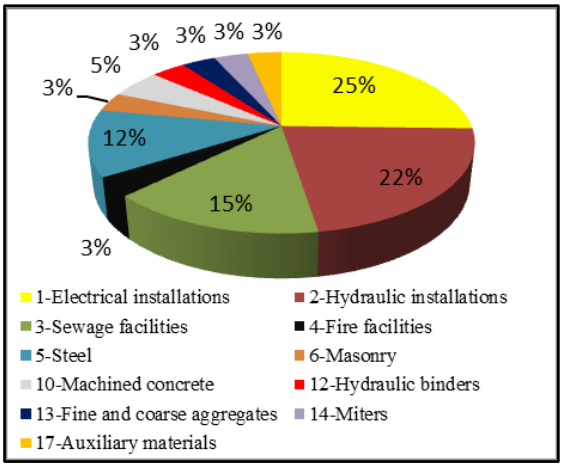

Fig. 2. Material inputs by group of services

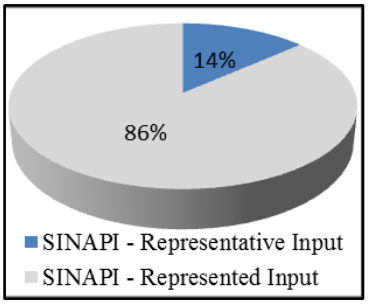

Fig. 3. Sample extracted from SINAPI for material inputs

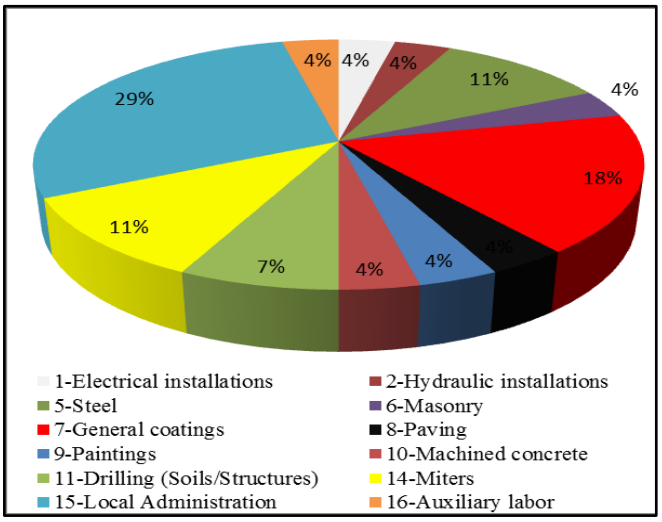

Fig. 4. Labor inputs by group of services

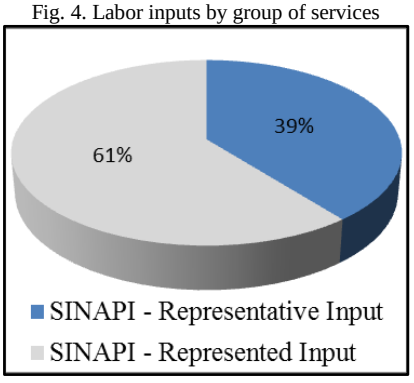

Fig. 5. Sample extracted from SINAPI for labor inputs

The market research corresponding to the technical specifications of material inputs proceeded with a minimum of three quotations, with the same base date, in distinct industrial and commercial establishments (wholesale and retail shops), and located in the state of Rio de Janeiro. A total of 49 suppliers took place in the research, a portion representing 20 of them contributed with quotations for more than one group of services, or contributed with quotations for different inputs of the same group of services. Tables III and IV, below, show the quantification in detail, and the profiles of the suppliers involved in the research.

TABLE III
Quantification of Suppliers According to the Profile and Acting Region

Acting region	Retailer	Distributor	Middleman	Distributor and Retailer	Manufacturer	Accredited Supplier	Total per Region
Metropolitan Region	12	4	-	7	3	3	29
Niterói - RJ	-	2	-	-	-	-	2
Macaé - RJ	-	1	-	3	10	-	14
Throughout the state of Rio de Janeiro	-	-	3	-	1	-	4
TOTAL	12	7	3	10	14	3	49
	24.5%	14.3%	6.1%	20.4%	28.6%	6.1%	100%

Note: Information transferred, through a statement, by the company Índice, Planejamento, Controle, Orçamento e Gestão Ltda.

TABLE IV
Quantification of Suppliers According to the Profile and Classification by Group of Services

No./ CLASSIFICATION		No. of suppliers per group	Retailer	Distributor	Middleman	Distributor and Retailer	Manufacturer	Accredited Supplier
1	Electrical installations	9	7	-	-	2	-	-
2	Hydraulic installations	13	9	-	-	4	-	-
3	Sewage facilities	8	5	-	-	3	-	-
4	Fire facilities	3	-	-	-	-	-	3
5	Steel	3	-	1	-	-	2	-
6	Masonry	8	-	-	-	-	8	-
10	Machined concrete	4	-	-	-	-	4	-
12	Hydraulic binders	6	2	1	-	3	-	-
13	Fine and coarse aggregates	3	-	2	-	1	-	-
14	Miters	6	-	3	3	-	-	-
17	Auxiliary materials	6	3	-	-	3	-	-
TOTAL		69	26	7	3	16	14	3

Note: Information transferred, through a statement, by the company Índice, Planejamento, Controle, Orçamento e Gestão Ltda.

The 59 material inputs had their data on reference and market costs organized and arranged together, so the selection of the minimum value was performed for the market research. Therefore, the Quotation Effect was reproduced, for representing something perfectly reasonable in any work when carrying out a minimum of three quotations proceeding with the choice of the lowest value, following the demonstrative example for an input, as seen in Table V below:

TABLE V
Arrangement of reference and market costs for material inputs

CA-50 Steel, 16 mm, Rebar.						
SOURCE	CODE	SUPPLIER	LOCAL	BASE DATE	UN.	R$
SINAPI	27*	-	RJ	may/15	kg	3.85
SCO/RJ	MAT000850	-	RJ	may/15	kg	2.44
SBC	3118	-	RJ	may/15	kg	2.53
QUOTATION 1**	-	PLANT	MACAÉ-RJ	may/15	kg	2.53
QUOTATION 2**	-	PLANT	MACAÉ-RJ	may/15	kg	2.64
QUOTATION 3**	-	DISTRIBUTOR	MACAÉ-RJ	may/15	kg	3.02

* Representative input. ** Information transferred, through a statement, by the company Índice, Planejamento, Controle, Orçamento e Gestão Ltda.

For the market research corresponding to labor inputs, it were adopted as market benchmarks the wage floor per worked hour by category, arising from the collective labor agreements, obtained from the Civil Construction Industry Unions - SINDUSCON of Rio de Janeiro and Norte Fluminense. Regarding the hand labor represented by professionals graduated in Engineering, it was adopted as a market benchmark the wage floor determined by Law No. 4.950 - A of April 22, 1966.

The municipalities involved in the research were Rio de Janeiro, Macaé and Conceição de Macabú (common collective agreement of the municipalities of Quissamã and Carapebus). The intention to make the hiring of labor with a remuneration that is minimally compatible with the wage floor was defined as a premise. Thus, the 28 inputs had their data on the costs of reference and market sources (without exoneration) organized and arranged together, hence, the selection of the maximum value was performed for the market research following the demonstrative example for an input, as can be seen below in Table VI:

TABLE VI
Arrangement of the reference and market costs for labor inputs

Foreman						
SOURCE	CODE	SITE	DURATION	BASE DATE	UN.	R$
SINAPI	4069*	STATE-RJ	-	may/15	H	40.53
SCO/RJ	MOI902400	STATE-RJ	-	may/15	H	31.59
SBC	99274	STATE-RJ	-	may/15	H	16.43
AGREEMENT 1**	-	MACAÉ-RJ	may/15 - apr/16	may/15	H	13.34
AGREEMENT 2**	-	C. DE MACABÚ-RJ	may/15 - apr/16	may/15	H	12.65
AGREEMENT 3**	-	RIO DE JANEIRO-RJ	may/15 - feb/16	may/15	H	17.74

*Represented input. ** Information transferred, through a statement, by the company Índice, Planejamento, Controle, Orçamento e Gestão Ltda., obtained with the SINDUSCON-RJ and NF.

The scale graphic representation that best describes the curves for the costs of material inputs, quoted in the period from November 2014 to July 2015, for SINAPI, SCO/RJ and SBC Informative, denotes proximity with respect to the Quotation Effect curve, as can be seen in figure 6 below:

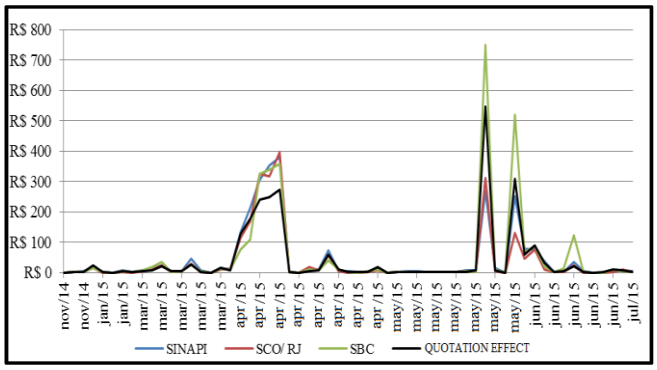

Fig. 6. Plotting of the costs involved in the experiment for material inputs

The scale graphic representation that best describes the curves for the costs of labor inputs, set on the base date of May 2015, for SINAPI, SCO/RJ and SBC Informative, denotes the proximity of the latter with respect to the curve of values representing the highest wage floor, as can be seen in figure 7 below:

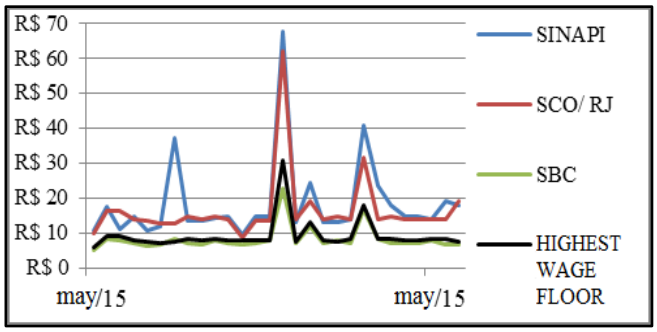

Fig. 7. Plotting of the costs involved in the experiment for labor inputs

A. Results

The search results for material and labor inputs were obtained by Equation 1. Its variables were named according to Table 7 and the results obtained are shown in Table 8:

$$R^2 = \left[\frac{\sum_{i=1}^{n} \left(x_i - \bar{x}\right) \cdot \left(y_i - \bar{y}\right)}{\sqrt{\sum_{i=1}^{n} \left(x_i - \bar{x}\right)^2} \cdot \sqrt{\sum_{i=1}^{n} \left(y_i - \bar{y}\right)^2}} \right]^2 \quad (1)$$

TABLE VII
Description of variables

DESCRIPTION	MATERIAL	LABOR
Pearson linear correlation coefficient	*R*1	*R*2
Coefficient of determination	$(R1)^2$	$(R2)^2$
QUOTATION EFFECT	*x*1	-
HIGHEST WAGE FLOOR	-	*x*2
SINAPI	*y*1	*y*4
SCO/RJ	*y*2	*y*5
SBC	*y*3	*y*6

TABLE VIII
Calculated results for material and labor inputs

Pair of Var.	Regression line Eq.	*R*1	$(R1)^2$
(*x*1 , *y*1)	*y*1 = 0.8293 *x*1 + 8.5316	0.8954	0.8018
(*x*1 , *y*2)	*y*2 = 0.8038 *x*1 + 4.1407	0.8905	0.7930
(*x*1 , *y*3)	*y*3 = 1.3550 *x*1 – 3.5507	0.9766	0.9538
Pair of Var.	Regression line Eq.	*R*2	$(R2)^2$
(*x*2 , *y*4)	*y*4 = 2.3022 *x*2 – 2.8973	0.8998	0.8097
(*x*2 , *y*5)	*y*5 = 2.0337 *x*2 – 2.3490	0.9794	0.9592
(*x*2 , *y*6)	*y*6 = 0.7253 *x*2 + 1.5083	0.9808	0.9620

The results that are closer to 1, presented by SBC, indicate the relevance regarding the preparation of the scatter plot and representation of the regression line for material and labor inputs, as can be seen in Figures 8 and 9 below:

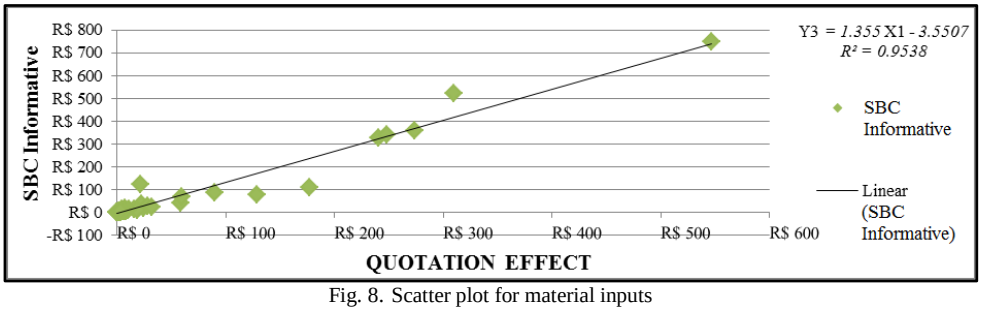

Fig. 8. Scatter plot for material inputs

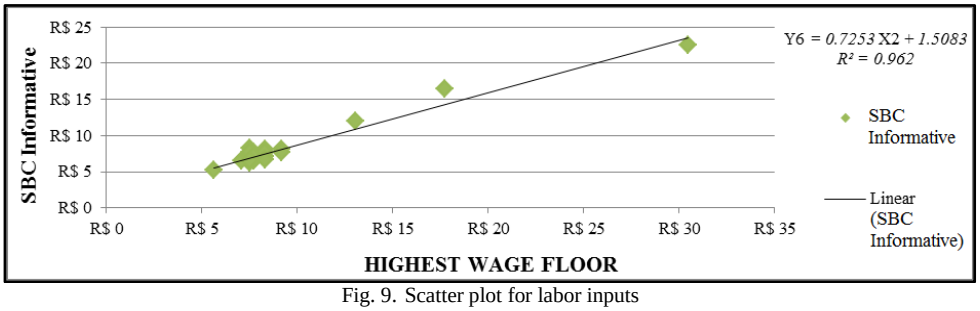

Fig. 9. Scatter plot for labor inputs

The results of 0.9766 and 0.9808, for the Informative SBC, corresponding to Pearson linear correlation coefficients, respectively, for samples of material inputs and labor inputs, indicate a linear correlation tending to perfection, being extremely close to 1, for the independent variables (X1) and (X2) related to the dependent variables (Y3) and (Y6). Similarly, the results of 0.9538 and 0.9620, corresponding to the determination coefficients, respectively, for samples of material inputs and labor inputs, indicate that 95.38% and 96.20% of the variation attributed to the variables (Y3) and (Y6) can be explained by the variables (X1) and (X2).

The search results for material inputs show that in the cases of SINAPI and SCO/RJ, the probabilities of occurrence of overpricing and/or underpricing may be higher, compared with the SBC Informative.

The search results for labor inputs clearly show that in the case of SBC Informative, the likelihood of occurrence of overpricing may be lower, compared with the SINAPI and SCO/RJ.

It should be noted that the research of this work is limited to an isolated analysis of input costs, disregarding the influence of the different productivity and consumption rates for the same service, cataloged in distinct reference systems.

Thus, the results presented by SBC should serve as a beacon only for the effective implementation of improvements regarding the methodology and statistical treatment used for research on costs along with unions and businesses.

B. Significance of results

The sample size, especially if it is small, is a factor that can influence the results for the Pearson correlation coefficient [14]. Therefore, based on the SINAPI and SBC that have populations, respectively, in the order of 5,000 and 17,000 inputs, taking into account material and labor inputs, it is set the need to estimate how significant are the main correlation coefficients resulting from the search. Considering that the sample, object of study of the present work, represents 1.74% and 0.51% of the total quantity of inputs provided respectively by SINAPI and SBC.

According to Lira and Neto [14], the significance of the value estimated for the Pearson correlation coefficient is determined through hypothesis testing. The test statistic for the hypothesis H0: P = 0 versus H1: P ≠ 0 has t-Student distribution with (n-2) degrees of freedom, according to Equation 2, as follows:

$$t = \frac{P\sqrt{n-2}}{\sqrt{1-P^2}} \sim t_{n-2}(2)$$

Wherein n is the number of observations for the sample and P is the correlation coefficient for the population. Despite the parameters adopted for the identification of the sample, object of study of this work, composed only of inputs that are comparable, with similar category and technical specification when extracted from different sources, it was assumed that P is R, linear coefficient to the sample, with t distribution for the following reasons:

- P coefficient is unknown;
- There is a large amount of inputs from civil construction, contained in the catalogs of the three sources involved in the research that are not comparable. One can find a given input in one or two sources only, notwithstanding, the verification with respect to the linear correlation of its costs becomes interesting while making an analysis without comparisons between sources. Then, there is the finding regarding the existence of evidence that in certain cases it is necessary to mix two or more official sources to define the overall cost in its entirety on a work of civil construction;
- Material inputs excluded from the sample, for presenting impracticability of obtaining quotations along with the trade, possibly for being already obsolete and unused;
- Labor inputs excluded from the sample, for presenting framing impossibility along with the constant ratings, in at least one of the collective agreements of the three municipalities involved in the research.

Thus, the values found for the variable t, two-tailed test, at a 99% confidence level, are described in Table 9 below:

TABLE IX
Calculated results for the t-Student test

Description	MATERIAL	LABOR
Pair of Variables	($x1$, $y3$)	($x2$, $y6$)
$R1$	0.9766	-
$R2$	-	0.9808
n	59	28
t	**34.28**	**25.64**
(n-2) g.l.	57	26
α	0.01	0.01
t (α/2,n-2)	**2.665**	**2.779**

According to the results listed in Table 5, where $t > t$ (α/2, n-2) with respect to the pairs of variables (X1, Y3) and (X2, Y6), H0: R = 0 is rejected. Therefore, it is concluded that the values of 0.9766 and 0.9808, obtained respectively for the samples of material and labor inputs are significant. Hence, there are correlations of 0.9766 and 0.9808, respectively, for the pairs of variables (X1, Y3) and (X2, Y6), with 1% significance level, that is, the likelihood of occurrence of such results by mere chance is less than 1%.

V. Conclusions

The result presented by SINAPI for the correlation coefficient, 0.8954 for material inputs, supports, despite the strong correlation, the fact that the phenomena causing distortions prevent the costs from the quoted source to reflect the market reality more accurately. Similarly, there is the SCO/RJ, with a correlation coefficient for material inputs equal to 0.8905, without knowledge of what are the reasons for such distortion.

The SBC Informative has a linear correlation close to perfection, equal to 0.9766 for material inputs, with confidence and significance levels, respectively, equal to 99% and 1%, reflecting, with less distortion compared to SINAPI

and SCO/RJ, the costs transacted in the market. Therefore, it is concluded that, among the three sources involved in the research, the unit costs of the SBC Informative for material inputs, considering their adoption to define the reference overall cost aimed at contracting works of civil construction with public funds, may have lower percentages of overpricing and/or underpricing. Resulting in greater economy, decreased incidence of overbillings in a veiled way, decreased margin for the occurrence of fraud and a remuneration increasingly compatible with the charges assumed by bidding agencies.

Regarding the search of labor inputs, hiring with a cost compatible with the wage floor, by category, was the focus of this work. This being so, the SCO/RJ and the SBC showed to be appropriate to do so by presenting linear correlations close to perfection, equal to 0.9794 and 0.9808, respectively, the second one presenting confidence and significance levels equal to 99% and 1%, respectively. However, if the goal is to make the hiring of labor with specific qualifications, based on great knowledge and long time experience, SINAPI shows to be appropriate to do so by presenting linear correlation equal to 0.8998, reasonably lower than the SCO/RJ and SBC. So, in this case, there is nothing to talk about overpricing and/or underpricing, much less about overbillings in a veiled way, but rather about which source of costs presents a remuneration compatible with the qualifications of labor requested by the object to be bid.

One can assume that the result attributed to SINAPI for material inputs has a reasonable contribution from the Correlation Effect, since 86% of the material inputs in the sample are represented inputs. Likewise for SCO/RJ, for the SBC Informative, the reasons to which one can assign the distortions in its costs are unknown. Since the methodology for obtaining the costs is not disclosed in the web page such as SINAPI, through a manual of methodologies and concepts. Therefore, a thorough study is necessary in connection with the methodology and the type of statistical analysis employed in the formation of SBC costs. In order to incorporate into the SINAPI, via benchmarking, innovations that come to favor increasingly the definition of costs that provide a remuneration compatible with the charges generated by the works of civil construction in Brazil.

It is important to note that small and medium-sized businesses, operating in the public works sector, should make investments for the implementation of Cost Engineering departments and the improvement of their legal departments. Thus, these companies would acquire greater expertise in assessing reference budgets proposed by the management, not being limited only to the “price dive” effect with high discounts to win the bid.

For further research, it is recommended to conduct a case study based on the characteristics and peculiarities of a large work, enabling the reproduction of the Bargain Effect. So that one can set coefficients of productivity and consumption for analytical compositions based on specifications and marketing costs. Thus, it will be feasible to correlate them to the analytical compositions of unit costs of SINAPI, SCO/RJ, SBC, among others, in order to point out which system has compositions that present remuneration with the highest level of compatibility with the charges generated by civil construction works in Brazil.

APPENDIX

TABLE X
Sample data (State-RJ) for material inputs [5, 17, 13]

No	BASE DATE	UN.	No** GROUP	SINAPI COD.	C/RC	y1 (R$)	SCO/RJ CODE	y2 (R$)	SBC COD.	y3 (R$)	X1* (R$)	X1.1* (R$)	X1.2* (R$)
1	nov/14	m	1	984	RC	**1.22**	MAT023550	**0.86**	4995	**0.85**	**0.67**	0.75	0.70
2	nov/14	m	1	982	RC	**3.14**	MAT023650	**1.96**	3579	**2.00**	**2.21**	2.42	2.39
3	nov/14	m	1	980	RC	**5.53**	MAT023700	**2.88**	3531	**3.98**	**3.45**	3.93	4.15
4	dec/14	un.	14	2429	RC	**18.96**	MAT049900	**16.69**	1505	**17.25**	**24.90**	26.20	28.90
5	jan/15	un.	1	12296	RC	**2.61**	MAT117500	**1.11**	12150	**1.40**	**3.50**	3.99	3.60
6	jan/15	m	1	983	RC	**0.89**	MAT021100	**0.37**	1089	**0.64**	**0.65**	0.75	0.67
7	jan/15	m	1	1004	RC	**9.51**	MAT021150	**3.10**	1297	**4.30**	**6.80**	7.29	7.15
8	jan/15	un.	1	1873	RC	**3.16**	MAT026150	**1.18**	4977	**1.52**	**2.40**	2.95	3.15
9	mar/15	m	2	9874	RC	**7.19**	MAT147100	**5.90**	10952	**9.52**	**5.58**	7.00	6.00
10	mar/15	m	2	9873	RC	**13.89**	MAT147200	**12.00**	36784	**18.39**	**7.50**	9.83	9.53
11	mar/15	m	2	9872	RC	**24.56**	MAT147300	**24.84**	13719	**35.31**	**23.15**	25.43	24.50
12	mar/15	un.	3	11071	RC	**6.72**	MAT104800	**2.74**	4835	**3.95**	**4.32**	5.58	5.19
13	mar/15	m	2	9869	RC	**4.93**	MAT147050	**4.11**	10951	**6.53**	**4.37**	4.72	5.16
14	mar/15	un.	2	11748	RC	**45.71**	MAT148950	**30.36**	70249	**26.00**	**27.97**	39.90	40.30
15	mar/15	un.	3	20155	RC	**7.01**	MAT074200	**3.02**	43611	**5.28**	**1.78**	2.10	2.19
16	mar/15	un.	2	3542	RC	**0.47**	MAT073850	**0.22**	2676	**0.26**	**0.40**	0.55	0.45
17	mar/15	un.	3	3670	RC	**16.59**	MAT075250	**9.87**	61335	**14.85**	**16.40**	19.70	18.39
18	mar/15	m	3	9836	C	**11.06**	MAT145250	**13.11**	4480	**11.30**	**8.02**	8.30	8.80
19	apr/15	un.	4	10886	RC	**134.59**	MAT054950	**114.00**	3286	**76.00**	**129.00**	129.00	146.55
20	apr/15	un.	4	10890	RC	**212.98**	MAT055250	**169.10**	36877	**110.00**	**177.00**	225.00	189.00
21	apr/15	m^3	10	1523	RC	**305.68**	MAT035950	**326.54**	50007	**326.84**	**241.00**	243.50	242.00
22	apr/15	m^3	10	1524	C	**353.00**	MAT036050	**317.15**	8420	**338.95**	**248.60**	250.00	251.30
23	apr/15	m^3	10	1525	RC	**380.25**	MAT036250	**396.57**	50008	**358.16**	**273.67**	277.13	285.20
24	apr/15	un.	6	25070	RC	**2.27**	MAT013150	**2.05**	7883	**2.34**	**1.85**	2.15	3.10
25	apr/15	Kg	12	1106	C	**0.64**	MAT026700	**0.21**	300	**0.45**	**0.33**	0.39	0.58
26	apr/15	m	3	9837	RC	**9.75**	MAT147250	**19.49**	87175	**10.98**	**5.27**	6.35	8.80
27	apr/15	un.	1	20010	RC	**12.29**	MAT047800	**8.58**	4896	**7.75**	**7.00**	7.99	8.25
28	apr/15	un.	1	74130/004	RC	**73.12**	MAT048100	**57.69**	4885	**39.95**	**58.96**	61.55	65.22
29	apr/15	Kg	17	13	RC	**5.28**	MAT054750	**5.80**	13083	**12.00**	**11.30**	13.13	13.49
30	apr/15	un.	1	1884	RC	**4.21**	MAT046200	**1.04**	3355	**2.26**	**1.75**	1.80	1.80
31	apr/15	m	1	2688	RC	**2.06**	MAT051800	**1.22**	5778	**1.32**	**1.65**	1.75	1.66
32	apr/15	m	1	2685	RC	**3.88**	MAT051350	**1.77**	3347	**6.33**	**3.63**	3.73	4.03
33	apr/15	un.	1	20111	C	**14.33**	MAT059450	**7.52**	36795	**9.80**	**18.90**	19.70	19.10
34	apr/15	un.	6	7270	RC	**0.55**	MAT135850	**0.58**	1950	**0.42**	**0.56**	0.65	0.58
35	may/15	m	2	9868	RC	**2.35**	MAT147000	**2.46**	51067	**3.05**	**1.83**	2.42	2.18
36	may/15	Kg	5	32	RC	**4.24**	MAT000650	**2.43**	779	**3.78**	**2.83**	2.91	3.41
37	may/15	Kg	5	33	RC	**4.76**	MAT000700	**2.35**	413	**3.78**	**2.83**	2.91	3.38
38	may/15	Kg	5	34	RC	**4.05**	MAT000750	**2.65**	778	**3.52**	**2.70**	2.77	3.17
39	may/15	Kg	5	31	RC	**3.85**	MAT000800	**2.52**	340	**3.28**	**2.53**	2.64	3.02
40	may/15	Kg	5	27	C	**3.85**	MAT000850	**2.44**	3118	**3.78**	**2.53**	2.64	3.02
41	may/15	Kg	5	29	RC	**3.60**	MAT000900	**2.48**	4728	**3.78**	**2.53**	2.64	3.02
42	may/15	Kg	5	337	C	**9.23**	MAT005700	**5.32**	400	**5.00**	**3.83**	4.38	4.84
43	may/15	un.	17	10	RC	**7.27**	MAT008650	**2.28**	4126	**3.00**	**8.35**	8.95	9.15
44	may/15	un.	2	11868	RC	**267.93**	MAT024850	**312.93**	4293	**749.90**	**546.76**	662.89	701.87
45	may/15	un.	3	7091	RC	**15.30**	MAT131950	**4.61**	3869	**11.14**	**8.29**	9.15	9.93
46	may/15	Kg	12	13284	RC	**0.40**	MAT033700	**0.36**	1	**0.50**	**0.43**	0.51	0.52
47	may/15	m^2	14	10507	RC	**250.55**	MAT152150	**130.00**	8425	**520.00**	**310.00**	325.00	328.00
48	jun/15	m^3	13	367	C	**79.18**	MAT006100	**45.25**	100	**68.50**	**60.00**	90.00	80.00
49	jun/15	m^3	13	4721	RC	**76.00**	MAT018500	**77.30**	8766	**88.00**	**90.00**	110.00	136.00

*Note: Information transferred, through a statement, by the company Índice, Planejamento, Controle, Orçamento e Gestão Ltda.
**Number of the group of services in which the input is classified, as seen in Figures 2 and 4 of this work.
C – Representative input/ RC – Represented input.

TABLE XI
Sample data (State-RJ) for material inputs [5, 17, 13]

No.	BASE DATE	UN.	No** GRoUP	SINAPI CODE	C/RC	y1 (R$)	SCO/RJ CODE	y2 (R$)	SBC CODE	y3 (R$)	X1* (R$)	X1.1* (R$)	X1.2* (R$)
50	jun/15	un.	3	1965	RC	**37.89**	MAT045400	**10.46**	4449	**21.00**	**31.80**	35.20	40.90
51	jun/15	un.	2	1923	RC	**3.92**	MAT045750	**1.56**	5396	**2.03**	**2.30**	3.90	2.53
52	jun/15	un.	2	6141	RC	**2.67**	MAT115600	**2.75**	17058	**13.00**	**4.73**	5.50	6.00
53	jun/15	un.	1	12216	RC	**36.24**	MAT078250	**25.90**	47081	**123.00**	**21.50**	22.24	22.20
54	jun/15	un.	1	1893	RC	**4.45**	MAT084350	**1.30**	43792	**2.20**	**1.75**	1.82	1.90
55	jun/15	un.	2	4210	RC	**0.56**	MAT091250	**0.40**	5714	**0.49**	**0.68**	0.79	0.70
56	jun/15	un.	2	798	RC	**0.67**	MAT019750	**0.24**	5746	**0.51**	**2.90**	3.20	3.50
57	jun/15	un.	3	5103	RC	**11.91**	MAT026600	**3.77**	43662	**10.00**	**10.65**	11.20	12.50
58	jun/15	un.	3	20087	RC	**7.52**	MAT028400	**10.63**	10501	**6.72**	**7.20**	9.39	8.50
59	jul/15	un.	2	119	C	**5.00**	MAT002150	**3.74**	3389	**3.43**	**3.95**	4.25	5.20

*Note: Information transferred, through a statement, by the company Índice, Planejamento, Controle, Orçamento e Gestão Ltda.
**Number of the group of services in which the input is classified, as seen in Figures 2 and 4 of this work.
C – Representative input/ RC – Represented input.

TABLE XII
Sample data (State-RJ) for labor inputs [5, 17, 13]

No	BASE DATE	UN.	No** GROUP	SINAPI CODE	C/RC	Y4 (R$)	SCO/RJ CODE	Y5 (R$)	SBC CODE	Y6 (R$)	X2* (R$)	X2.1* (R$)	X2.2* (R$)
1	may/15	H	16	6111	C	**10.59**	MOD902450	**10.00**	99900	**5.20**	**5.62**	4.56	4.56
2	may/15	H	15	253	C	**17.30**	MOI900100	**16.34**	99018	**8.07**	**9.18**	6.26	6.57
3	may/15	H	15	6122	RC	**10.94**	MOI900150	**16.34**	99148	**7.70**	**9.18**	5.30	5.60
4	may/15	H	5	378	C	**14.62**	MOD900450	**13.75**	99300	**7.15**	**7.76**	6.26	6.57
5	may/15	H	15	244	RC	**10.68**	MOI900600	**13.61**	91086	**6.30**	**7.54**	6.26	6.57
6	may/15	H	15	2350	RC	**11.96**	MOI900500	**12.65**	99873	**6.57**	**7.10**	4.60	4.70
7	may/15	H	15	528	RC	**37.10**	MOI900700	**12.65**	91085	**8.28**	**7.54**	6.26	6.57
8	may/15	H	7	4760	RC	**13.30**	MOD901300	**14.80**	99100	**7.15**	**8.35**	6.26	6.57
9	may/15	H	8	4759	RC	**13.45**	MOD900750	**13.75**	99600	**6.50**	**7.76**	6.26	6.57
10	may/15	H	14	1214	RC	**14.41**	MOD900800	**14.80**	99360	**7.70**	**8.35**	6.26	6.57
11	may/15	H	10	1213	C	**14.62**	MOD900850	**13.75**	99350	**7.15**	**7.76**	6.26	6.57
12	may/15	H	11	4235	RC	**9.30**	MOD900900	**8.75**	99080	**6.50**	**7.76**	6.26	6.57
13	may/15	H	1	2436	C	**14.62**	MOD900950	**13.42**	99250	**7.15**	**7.76**	6.26	6.57
14	may/15	H	2	2696	C	**14.62**	MOD900650	**13.42**	99200	**7.70**	**7.76**	6.26	6.57
15	may/15	H	15	2706	C	**67.39**	MOI901600	**61.95**	99012	**22.50**	**30.45**	30.45	30.45
16	may/15	H	7	12865	RC	**12.90**	MOD901050	**13.75**	99140	**7.15**	**7.54**	6.26	6.57
17	may/15	H	15	4083	C	**24.33**	MOI901500	**19.11**	99015	**11.95**	**13.04**	12.37	12.91
18	may/15	H	7	12872	RC	**12.90**	MOD901150	**13.75**	99315	**7.15**	**7.76**	6.26	6.57
19	may/15	H	14	12868	RC	**13.13**	MOD901350	**14.80**	99014	**7.70**	**7.54**	7.37	7.37
20	may/15	H	7	4755	RC	**13.77**	MOD901400	**13.75**	99398	**7.15**	**8.35**	6.26	6.57
21	may/15	H	15	4069	RC	**40.53**	MOI902400	**31.59**	99274	**16.43**	**17.74**	12.65	13.34
22	may/15	H	5	2700	RC	**23.53**	MOD901800	**13.90**	99022	**8.07**	**8.35**	6.87	7.20
23	may/15	H	7	4751	RC	**17.65**	MOD902100	**14.80**	99538	**7.15**	**8.35**	6.26	6.57
24	may/15	H	6	4750	C	**14.62**	MOD902150	**13.75**	99050	**7.15**	**7.76**	6.26	6.57
25	may/15	H	9	4783	C	**14.62**	MOD902200	**13.75**	99550	**7.15**	**7.76**	6.26	6.57
26	may/15	H	14	6110	RC	**13.83**	MOD902400	**13.75**	99230	**7.70**	**8.35**	6.26	6.57
27	may/15	H	5	6160	C	**18.88**	MOD902500	**13.75**	99027	**6.72**	**8.35**	6.26	6.57
28	may/15	H	11	6173	RC	**17.94**	MOD902550	**19.11**	99326	**6.50**	**7.54**	6.26	6.57

*Note: Information transferred, through a statement, by the company Índice, Planejamento, Controle, Orçamento e Gestão Ltda.
**Number of the group of services in which the input is classified, as seen in Figures 2 and 4 of this work.
C – Representative input/ RC – Represented input.

REFERENCES

[1] BAETA, A. P. Orçamento e controle de preços de obras públicas. São Paulo: Pini, 2012.

[2] BERNARDES, E. G.; TONDATO, A. S.; CHIABI, B. R. T. C.; ESTRELLA, F.; GUTIERREZ, F.; AMARAL, J.; VILELA, R. B. M.; BRANT, M.; GIL, R.; FARRER, R.; REIS, R.; RUGGIO, R. Administração contratual & Claim: coexistência pacífica dos aspectos jurídicos e de engenharia em obras. São Paulo: Pini, 2015.

[3] BRASIL. Caixa Econômica Federal. Manual de Metodologias e Conceitos do SINAPI – versão 5, 2015a. Disponível em: <http://www.cef.com.br>. Acesso em 31 de mai. de 2015.

[4] BRASIL. Caixa Econômica Federal. Sistema Nacional de Pesquisa de Custos e Índices da Construção Civil - SINAPI - Preço de referência para insumos desonerados. Disponível em: <http://www.cef.com.br>. Acesso em 02 de out. de 2015.

[5] BRASIL. Decreto nº 7.983, de 8 de abril de 2013a. Estabelece regras e critérios para elaboração do orçamento de referência de obras e serviços de engenharia, contratados e executados com recursos dos orçamentos da União, e dá outras providências. Diário Oficial [da] República Federativa do Brasil. Poder Legislativo, Brasília, DF.

[6] BRASIL. Ministério do Planejamento, Orçamento e Gestão. Instrução Normativa SLTI – Secretaria de Logística e Tecnologia da Informação nº 7, de 29 de agosto de 2014a. Altera a Instrução Normativa nº 5, de 27 de junho de 2014, que regulamenta os procedimentos administrativos básicos para realização de pesquisa de preços. Disponível em: <http://www.comprasgovernamentais.gov.br>. Acesso em 04 de jul. de 2015.

[7] BRASIL. Tribunal de Contas da União. Orientações para elaboração de planilhas orçamentárias de obras públicas. Coordenação-Geral de Controle Externo da Área de Infraestrutura e da Região Sudeste. Brasília: TCU, 2014b. Disponível em: <http://portal2.tcu.gov.br/portal/pls/portal/docs/2675808.PDF>. Acesso em 04 de jan. de 2015.

[8] BRASIL. Tribunal de Contas da União. Acórdão TCU nº 1.266/2011 - Plenário. Relator: Ubiratan Aguiar. Ata nº 18/2011 – Plenário, sessão: 18 mai. 2011. Disponível em: <http://portal.tcu.gov.br/cidadao/cidadao.htm>. Acesso em 13 de jul. de 2015.

[9] BRASIL. Tribunal de Contas da União. Acórdão TCU nº 2.984/2013c - Plenário. Relator: Ministro José Múcio Monteiro. Ata nº 43/2013 – Plenário, sessão: 06 nov. 2013. Disponível em: <http://portal.tcu.gov.br/cidadao/cidadao.htm>. Acesso em 13 de jul. de 2015.

[10] Dantas, J. F. F. L. Avaliação do uso de custos dos insumos do SINAPI em unidades habitacionais populares. In Anais do XIII SINAOP - Simpósio Nacional de Auditoria de Obras Públicas, Porto Alegre, 2010.

[11] FILHO, L. de O. e S.; LIMA, M. C.; MACIEL, R. G. Efeito barganha e cotação: fenômenos que permitem a ocorrência de superfaturamento com preços inferiores às referências oficiais. In: XIII SINAOP - Simpósio Nacional de Auditoria de Obras Públicas, Porto Alegre, 2010.

[12] INFORMATIVO SBC – SISTEMA DE BOLETIM DE CUSTOS. *Catálogo de insumos.* Rio de Janeiro, 2015. Disponível em: <http://www.informativosbc.com.br/>. Acesso em 02 de out. de 2015.

[13] LEITÃO, A. J. Obras públicas: artimanhas e conluios. 4ª ed. São Paulo: Liv. e Ed. Universitária de Direito, 2013.

[14] LIRA, S. A.; NETO, A. C. Coeficientes de correlação para variáveis ordinais e dicotômicas derivados do coeficiente linear de Pearson. *Revista Ciência & Engenharia*, Uberlândia: EDUFU, v. 15, n. 1/2, p. 45-53, jan.-dez. 2006.

[15] MENDES, A. Aspectos polêmicos de licitações e contratos de obras públicas. São Paulo: Pini, 2013.

[16] RIO DE JANEIRO. Prefeitura Municipal. Secretaria Municipal de Obras. Catálogo de itens SCO/RJ - Sistema de Custos de Obras. Disponível em: <http://www2.rio.rj.gov.br/sco/>. Acesso em 02 de out. de 2015.

[17] TISAKA, M. Como evitar prejuízos em obras de construção civil: Construction CLAIM. São Paulo: Pini, 2011.

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