

## Identifying Behaviors and Irregularities in Public Procurement in the Brazilian Federal Government

André Castro, Daniel Rogério, Rodrigo Marquez, Wesley Lira from Ministry of Planning, Development and Management – MP and Caio Costa from University of Brasilia - UnB

### ABSTRACT

Public procurement in Brazil is responsible for a large volume of resources and consequently has a high level of importance for the country's economy. The evolutions in frameworks and legal devices that surround the theme have shown a concern with the improvement of the processes responsible for guaranteeing the supply of goods and services for the Brazilian State in its three spheres, federal, state and county.

Concerned with the continuous improvement of these processes, Ministry of Planning, Development and Management, responsible for regulating and monitoring the processes and information systems of federal public procurement, seeks to identify supplier behaviors in electronic reverse auctions that hurt the isonomy of these processes, specifically with the use of bots for automatic bidding, fraud in the exclusive use of benefits for micro company and small Business (MC/SB) and also in the identification of collusions between suppliers with the presence of "rabbits".

In such analyzes, a hybrid antifraud approach was applied through existing solutions in the SAS® Fraud Framework. The results indicate that, among other points, the methodologies defined support the previously established objectives, and allowed the identification of many suppliers with indications that they used benefits improperly, damaging the economic policy implemented, collusion and presence of "rabbits", and the impact of the use of automatic bidding mechanisms from a cost-effective perspective.

The results obtained lead to strategic discussions in terms of economic policy and wide competition and allow the review/improvement of public procurement processes in Brazil to ensure equal conditions for participants, selection of the most advantageous offer for public administration and preservation of the policies adopted.

### INTRODUCTION

Between 2015 and 2017, public procurement made by public administration agencies in Brazil via the General Services Information and Administration System (Sistema Integrado de Informações e Serviços Gerais - SIASG) - the main public procurement system in the country – with values around of R\$ 160 billion reais or almost US\$ 50 billion dollars<sup>1</sup>.

It is important to highlight that the main mechanism used in public procurement in Brazil is the electronic reverse auction.

In addition to the importance of public procurement for the country's economy, the high volume of processes illustrates the challenge of ensuring compliance with the constitutional principle of isonomy and the selection of the most advantageous proposal for public administration as defined in Article 3 of Law 8666/1993 (BRAZIL, 1993), the main legal instrument that regulates issues related to public procurement.

The Ministry of Planning, Development and Management, with the purpose of guaranteeing compliance with these precepts expressed in the legislation, has turned its concerns, among other aspects, to the identification of improper use of legal benefits for Micro Company (MC) and Small Business (SB), the identification of "rabbits" associated with the formation of collusions, sale of position (for money or through intermediation of delivery) and evaluate the impact of the use of bots for automatic bidding on government purchases made through electronic reverse auction.

<sup>1</sup> More information at: <http://paineldecompras.planejamento.gov.br>

To achieve these objectives, a hybrid anti-fraud approach was applied through the solutions in the SAS© Fraud Framework. The objective of this work is based on the discussion of the tracks identified by the Ministry of Planning, Development and Management (MP), highlighting the methodologies and the main results found, as well as the expected results for the public administration.

## **METHODOLOGY**

Using transaction data stored in SIASG's Database Management System (DBMS), it was possible to apply various business rules associated with specific behaviors to detect evidence of irregularities.

The SAS © Enterprise Guide, SAS © Base and SAS © Enterprise Miner tools were used for the development of the project to analyze data of electronic reverse auctions between 01/2015 and 11/2017.

To achieve the proposed objectives, and to overcome the difficulties in identifying suspicious behavior, several methodologies were employed on three fronts.

The first step was the selection, preparation, and integration of the data, which consists in the organization of the raw data presented allowing the subsequent analysis. Through SAS © code, the data was cleaned and processed, as well as the construction of derived variables from this process.

In the process, the integration of data extracted from the main system of financial execution of Brazil, the Integrated System of Financial Administration of the Federal Government - SIAFI was carried out. The registration, monitoring and control of the budget, as well as financial and patrimonial execution of the Federal Government is responsibility of SIAFI.

To understand and summarize the elaborated tables, initial descriptive statistics were generated, allowing a strategic view of the data, subsidizing the sequential stages. Based on this second step, a large set of tables and graphs were generated. These allowed an exploratory view of existing information.

More sophisticated techniques were used, including the construction of business rules to verify compliance with Brazilian legislation, analysis of data distribution to identify atypical behavioral patterns and the use of data mining techniques. Each of the described approaches was used in one of the lines of research using one of the SAS © tools most suitable for each task.

The methodologies used for each of the fronts are described in more detail below.

## **EVIDENCES OF ILLEGAL USE OF BENEFITS FOR MICRO COMPANY (MC) AND SMALL BUSINESS (SB)**

The undue use of benefits for Micro Company (MP) and Small Business (SB) indicated in Complementary Law 123, from December 14<sup>th</sup> of 2006, compromises the effects of public policy.

This legislation was created to enable the most effective participation of these companies in public procurement, thus allowing a universalization of the participation and insertion of economic actors, hitherto without protagonism in government procurement processes, as Cabral, Reis and Sampaio (2015) point out.

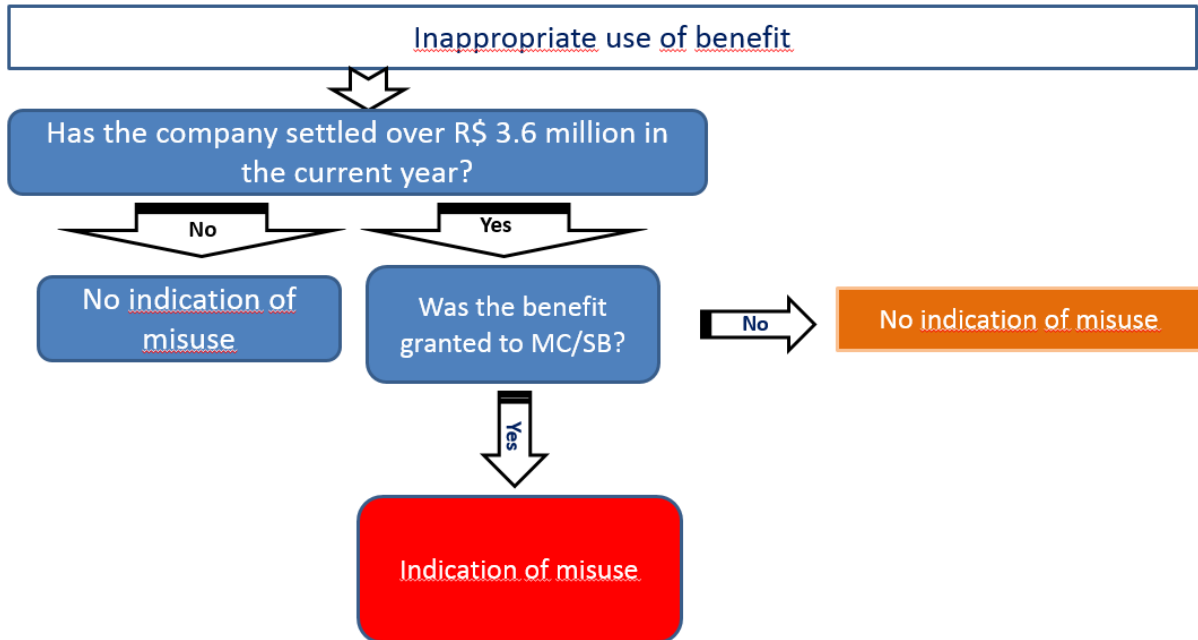
To improve standards and benefits and improve the system to increase the effectiveness of economic and social policies of important benefits for the economic and social development of the countries (Preuss, 2011; Nakabayashi, 2013). it is essential to identify the misuse of the privileges hitherto granted.

This vulnerability is due to two basic factors: the lack of compliance with the company's size declaration (occurs in April) and the fiscal year (January to December), and due to the self-declaration of size for use of the benefit in the purchasing system.

This identification was made based on business rules that aim to compare the information extracted from the data with what is defined in the legislation on the subject. These rules were aimed at finding companies that were benefited by the legislation and have an annual billing of more than R\$ 3.6 million (three million and six hundred thousand reais) or almost \$ 1.0 million (1 million dollars) and, therefore, do not fit the legal requirements.

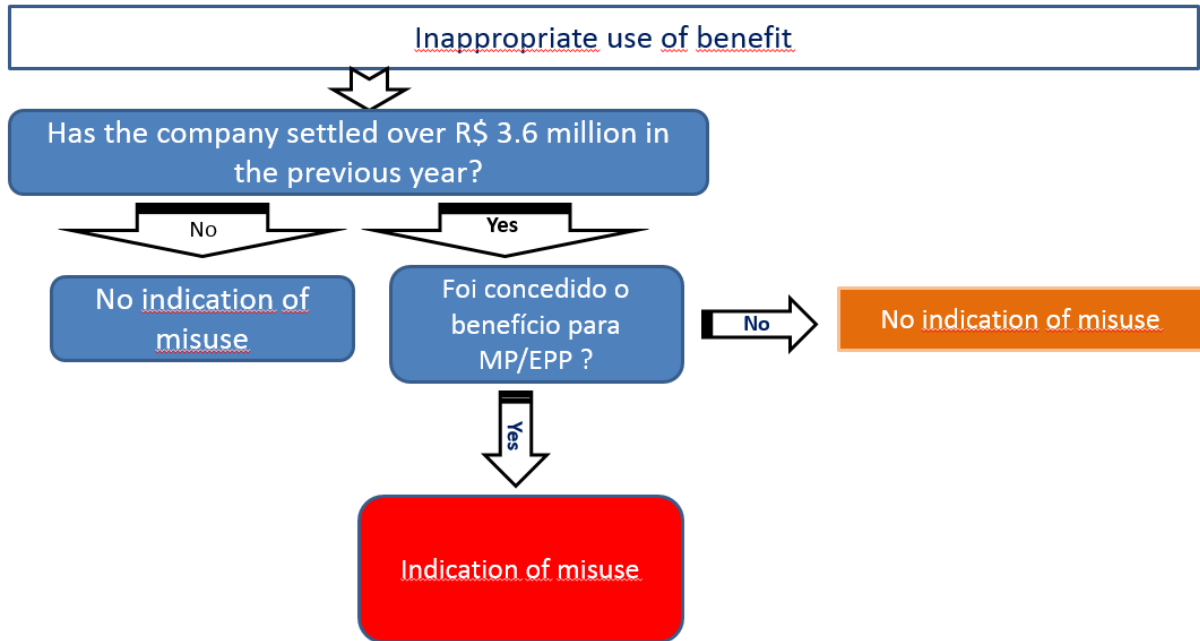
Such problem was pointed out in recent plenary judgment of the Union Court of Auditors when recommend to the auctioneers, who are responsible for the qualifications of the companies in the bidding processes, to verify the conformity of the companies that win the electronic reverse auction using benefits.

To identify companies that have already exceeded this limit and would still be using these benefits in government purchases, two rules were considered, presented in the following figures:



Erro! Fonte de referência não encontrada.: Companies that, in the current year, settled more than R\$ 3.6 million, but continued to declare MC/SB size in electronic reverse auction after they had crossed the limit.

In the sequence, figure number 2 demonstrates similar procedure however with a different business rule.



Erro! Fonte de referência não encontrada.: Companies that, in the previous year, settled more than R\$ 3.6 million and continue to declare MC/SB in electronic reverse auction in the next year.

Thus, the supplier that meets at least one of these established rules will be marked with an indicator of undue use of benefit.

A macro was also created in SAS © language to automate the consultation of the monthly evolution of the settlements for a certain supplier.

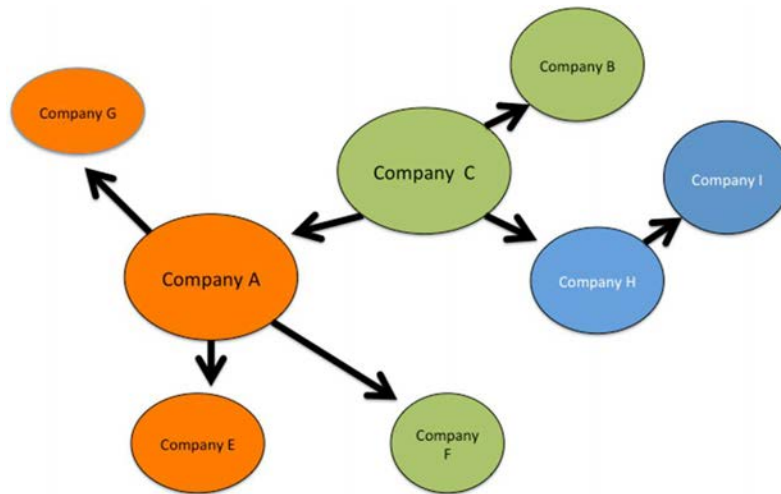
### IDENTIFICATION OF “RABBITS” TO INDICATE POSSIBLE COLLUSIONS OR POSITION SALE (BY MONEY OR BY DELIVERY INTERMEDIATION)

The “rabbits” are defined as those bidders who act in a way to reduce prices in the first moments of the bidding process to discourage the participation of other bidders in the bidding stage. Analogy made to the “rabbit” present in “horseracing”.

However, these “rabbits” eventually give up the competition to benefit another company with which it has colluded (Campelo, 2011). The performance of the “rabbits” makes less favorable proposals are chosen leading to a series of losses to the public administration. Such losses are catalyzed by the occurrence of collusion associated with the “Rabbit”, aggravated by the repeated occurrences

The identification of collusion cases was performed using a data mining technique known as market analysis. The technique in question relies on membership rules to determine the dependence of events that, in theory, would be independent. In this case, we seek to analyze the relationship of dependence on the participation of two companies in the same bidding processes.

The following image represents the previously elucidated question.



Erro! Fonte de referência não encontrada.s

The identification of "Rabbits" was defined as follows:

**Step 1:** Identification of the suppliers that have a high level of association, i.e., that participate in the same processes of purchases frequently. The level of association was measured using the "lift" method, which indicates how frequent the company A participate in a bidding process, given that company B also participated.

Equation defines the lift method 1:

$$lift = \frac{P(A \cap B)}{P(A)P(B)} = \frac{P(B|A)}{P(B)} \quad (1)$$

**Step 2:** Considering the occurrence of a strong level of association between companies, in this second stage we aim to analyze the metrics related to participation, victories and disqualification of these companies strongly associated. Thus, if Company A and G have a high level of association, and Company G has a very high number of declassifications when Company A is a winner, so Company G may be a "Rabbit" in collusion with A.

The combination of these two stages allows the identification of undue associations in the bidding process of companies that seek to obtain their own benefits.

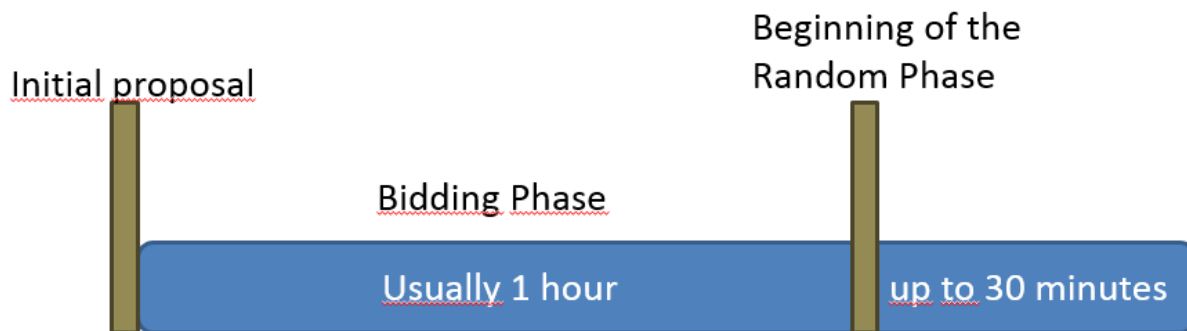
This scenario can also be represented by the following questions:

1. Which suppliers have many wins without being in first place?
2. In these cases, which companies were disqualified in best positions? What is the frequency?

## EVALUATE THE IMPACT BY USING BOTS FOR AUTOMATIC BIDS IN ELECTRONIC REVERSE AUCTION

To evaluate the impact by using bots for automatic bids in electronic reverse auction, more than 100 million bids were presented during the period from January 2015 to November 2017.

The concern with this issue becomes relevant due to the principle of isonomy established in article 3 of Law 8.666 / 1993, which defines equal treatment for similar situations and different treatment for different situations, as stated by Lima & Silva (2011). The advantage of using a bot is due to the step known as the "random phase", which can be terminated at any time up to 30 minutes at random.



**Erro! Fonte de referência não encontrada.** Auction Phases

In these situations, the speed of each bid can be crucial to set the winner, generating a "disadvantage" for those who do not have a tool for automatic bid generation. That is, in practical terms, whenever a bid is made, the automatic tool can bid better in a very fast way.

Considerando tais aspectos, a avaliação dos impactos da sua utilização poderá ser útil para balizar e nortear a construção de políticas e melhoria de processos para lidar com tal questão.

Business rules were built to identify the bids that were supposedly sent through automatic bidding mechanisms.

The rules used were created based on an exploratory analysis of the data and the human impossibility of performing the necessary calculations in extremely short periods, typing, and submitting a bid.

In addition, it was also considered as bids coming from bots those who have aggressive behavior where more than 80% of the bids had an interval less than 5 seconds.

The proposed business rules are as follows:



**Figure 4:** Business Rules

After the identification of the use of bots, data crossings were performed to visualize the relationships between the percentage of use of bots versus the total of participants, as well as the means of price reduction when comparing the prices presented at the beginning of the random phase and the final price.



## RESULTS AND DISCUSSIONS

The results of the analyzes carried out will be presented separately with the care of safeguarding sensitive information and sensitive content.

The results will be presented in sequential order according to the aforementioned methodology session. The presentations differ, especially in relation to the depth and analyzes scope. This is due not only to the different scopes, but also to the maturity of each work and the possibilities of explorations and analyzes in advance.

### EVIDENCES OF ILLEGAL USE OF BENEFITS FOR MICRO COMPANY (MC) AND SMALL BUSINESS (SB)

By applying the rules set out in the initial subtopic on the methodology, hundreds of suppliers were identified that are included in the parameters of misuse, related to thousands of purchase items, in hundreds of millions of dollars involved.

So far, it has not been possible to validate the information with the competent tax agency to analyze possible economic rules that justify certain behaviors. In this way, the presented values are treated as possible indications and foment the discussion about the agenda.

Based on the SAS® language, a macro was created to meet the described methodology and enabled the instantaneous investigation of the situation of each company and the volume of resources committed for that period, as well as its monthly evolution.

Queries performed provide the following outputs:

		RS		13.909.097,65			
ID_COMPRA	id_gitem_compra	DS_CMPR_COMPRA_EDIT	valor_compra_revisado	dt_abert_sessao	empenho_acumulado	empenho_ano_anterior	TRILHA
660514	G00000001		326.933,57	02MAR2015	5415618,86		Acima do limite no ano corrente
659987	G00000001		600.000,01	10MAR2015	5415618,86		Acima do limite no ano corrente
662602	G00000001		954.000,00	27MAR2015	5415618,86		Acima do limite no ano corrente
662408	010715025		99.437,62	14APR2015	8420876,6		Acima do limite no ano corrente
662408	010715026		192.653,00	14APR2015	8420876,6		Acima do limite no ano corrente
665183	010736911		97.867,02	27APR2015	8420876,6		Acima do limite no ano corrente
664222	G00000001		3.723.429,05	15MAY2015	11762779,52		Acima do limite no ano corrente
664026	G00000001		272.300,40	18MAY2015	11762779,52		Acima do limite no ano corrente
664054	010725916		150.000,00	19MAY2015	11762779,52		Acima do limite no ano corrente
664054	010725917		30.000,00	19MAY2015	11762779,52		Acima do limite no ano corrente
664054	010725918		14,16	19MAY2015	11762779,52		Acima do limite no ano corrente
664054	010725919		14,16	19MAY2015	11762779,52		Acima do limite no ano corrente
666610	G00000001		385.294,00	27MAY2015	11762779,52		Acima do limite no ano corrente
667400	G00000001		89.961,86	01JUN2015	14781274,28		Acima do limite no ano corrente
667400	G00000002		4.131,03	01JUN2015	14781274,28		Acima do limite no ano corrente
667400	G00000003		5.528,52	01JUN2015	14781274,28		Acima do limite no ano corrente
667400	G00000004		102.585,47	01JUN2015	14781274,28		Acima do limite no ano corrente
667400	G00000005		13.494,71	01JUN2015	14781274,28		Acima do limite no ano corrente
667400	G00000006		24.233,35	01JUN2015	14781274,28		Acima do limite no ano corrente
668392	010759981		198.635,52	08JUN2015	14781274,28		Acima do limite no ano corrente
668392	010759982		299.653,03	08JUN2015	14781274,28		Acima do limite no ano corrente
200182549	G00000001		279.335,80	10JUL2015	18821348,96		Acima do limite no ano corrente
673875	G00000001		130.200,01	22JUL2015	18821348,96		Acima do limite no ano corrente
673428	010805389		30.468,36	31JUL2015	18821348,96		Acima do limite no ano corrente
200184916	210017717		707.976,00	11AUG2015	21136647,64		Acima do limite no ano corrente
200184916	210017718		1.982.332,80	11AUG2015	21136647,64		Acima do limite no ano corrente
200184916	210017719		379.062,15	11AUG2015	21136647,64		Acima do limite no ano corrente
200184916	210017720		33.038,87	11AUG2015	21136647,64		Acima do limite no ano corrente
200184916	210017721		114.220,12	11AUG2015	21136647,64		Acima do limite no ano corrente
200184916	210017722		183.601,77	11AUG2015	21136647,64		Acima do limite no ano corrente
672257	010791087		750.646,40	17AUG2015	21136647,64		Acima do limite no ano corrente
684302	G00000001		249.151,00	05NOV2015	30314329,7		Acima do limite no ano corrente
682104	G00000001		317.803,67	11NOV2015	30314329,7		Acima do limite no ano corrente

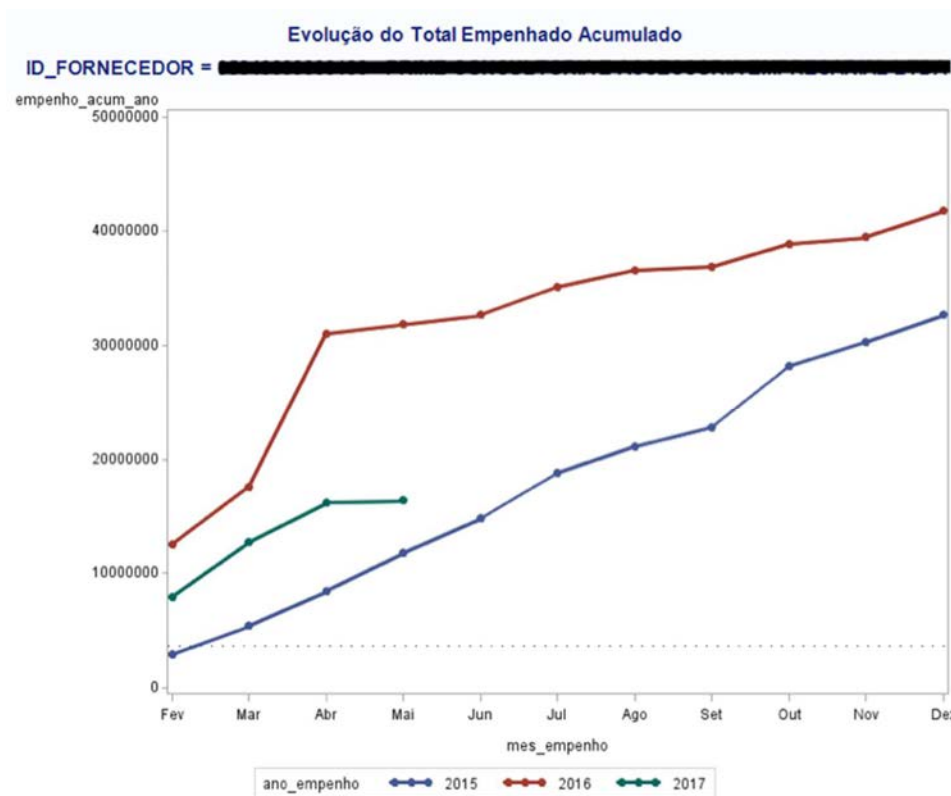
Figure 5: MC/SB Benefits Misuse Verification Chart

The table allows for consultations to the values realized having the governmental agencies as beneficiary. In this way, it is possible to identify the exact moment when the limit established in Law is exceeded, as well as the identification of the processes which the supplier used the benefit after exceeding the limit, being able to calculate, for example, the possible losses imposed to the public administration, and therefore, an indicator of fraud in the bidding process.

The previous example reports a case in which all the analyzed purchases of the same company can be characterized as misuse of the benefit, since in the previous year the company in question, whose name will not be presented for reasons of secrecy, had a cumulative total of settled amounts of R\$ 13.909,097,65.

Analyzing the presented company, only the amount settled for the previous year is 3.86 times the limit for use of benefits.

Another way of visualization can be done via a graph that presents the evolution of the value month by month, allowing an aggregated view of the situation and complementing the table.



**Figure 6:** Monthly evolution of accumulated settlement value

The values obtained by the analyzes refer only to what the public administration and the users of the SIASG System have approved purchase results, not binding the financial and contractual execution of the entire value.

The amount referred to the limits for Micro Companies and Small Business refers to the amount settled in SIAFI, which implies in revenues to the companies related only with Federal Government. That is, it does not contemplate any agencies from other spheres that do not use the system, as well as the negotiations made with the private sector.

These results demonstrate the need to integrate other government databases and create alerts in real time for occasions when values exceed the threshold and may be a great value limiting the misuse of benefits.

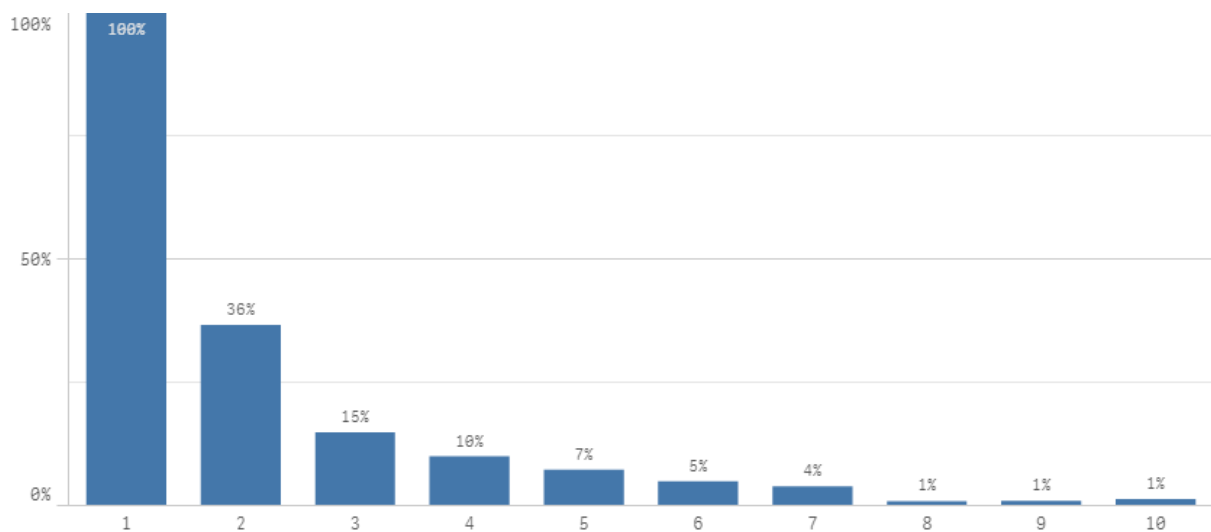
This practice diminishes the effectiveness and efficiency of the public policy that aims to insert Micro Companies and Small Companies in the role of government suppliers, as well as indicators of economic result regarding the participation of the State in the growth of companies.



## IDENTIFICATION OF “RABBITS” TO INDICATE POSSIBLE COLLUSIONS OR POSITION SALE (BY MONEY OR BY DELIVERY INTERMEDIATION)

Among the work fronts, identifying and signaling possible collusions is the one that needs to be deepened considering the results analysis. The build of the database based on data from SIASG allowed us to discover patterns and associations between companies and the calculation of certain statistics for these associated companies, which are as follows: Number of participations; Number of victories; Number of victories in 1st place; Number of calls to homologate the results; Number of calls in 1st place; Number of declassifications; Number of declassifications in 1st place; Total amount approved.

Through the analyzes, it is verified, for example, the probability of calling to provide the good or to provide the service according to the classification in the contest.



**Graph 1** – Probability of calling according to the vendor's position at the end of the electronic reverse action.

The graph shows the probability of being called to provide the service or good given the placement of the supplier, i.e. the probability of a disqualification of all higher positions.

This indicator serves as an incentive for suppliers to maintain reasonable prices for certain goods and services even if other suppliers have lower prices. In a very objective way, it is worthwhile to be the 3rd or 5th place, for example.

In addition, considering the main objective of the work, the calculation of these indicators allowed the identification of the possible rabbits, which can generate damages to the public administration with this practice, since presenting a very low price can discourage the others to continue competing in the contest, so that the second place can present a price with a higher profit margin, which price will be paid by the public administration in case of disqualification of the first.

The identification of these cases allows to analyze the behaviors of these "rabbits" and the existing associations, which allows to carry out the actions to curb this practice, either through the improvement of the electronic processes, or through responsible punishment, when possible.

Due to the sensitivity of this information, the results of the market basket analysis for the cases in question could not be presented. To illustrate the form of construction of the results, the table generated with SAS © communities library meets the purpose.

Relations	Expected Confidence(%)	Confidence(%)	Support(%)	Lift	Transaction Count	Rule	Left Hand of Rule	Right Hand of Rule	Rule Item 1
2	9.49	61.90	9.49	6.52	13.00	mutual_fun...	mutual_fund	new_job	mutual_fund
2	8.03	52.38	8.03	6.52	11.00	marriage =...	marriage	CD	marriage
2	15.33	100.00	9.49	6.52	13.00	new_job ==...	new_job	mutual_fund	new_job
2	15.33	100.00	8.03	6.52	11.00	CD ==> ma...	CD	marriage	CD
2	16.79	100.00	8.76	5.96	12.00	graduate =...	graduate	close_loan	graduate
2	8.76	52.17	8.76	5.96	12.00	close_loan ...	close_loan	graduate	close_loan
2	13.87	67.86	13.87	4.89	19.00	open_loan ...	open_loan	savings	open_loan
2	20.44	100.00	13.87	4.89	19.00	savings ==...	savings	open_loan	savings
2	27.74	100.00	15.33	3.61	21.00	mutual_fun...	mutual_fund	credit_card	mutual_fund
2	15.33	55.26	15.33	3.61	21.00	credit_card ...	credit_card	mutual_fund	credit_card
2	27.74	100.00	9.49	3.61	13.00	new_job ==...	new_job	credit_card	new_job
2	31.39	100.00	20.44	3.19	28.00	open_loan ...	open_loan	money_ma...	open_loan
2	20.44	65.12	20.44	3.19	28.00	money_ma...	money_ma...	open_loan	money_ma...
2	31.39	100.00	13.87	3.19	19.00	savings ==...	savings	money ma...	savings

Figure 7: Table Rules – Source: SAS (2018)

If the Lift method presented in column number five is higher, then the association between two objects is higher too.

It is possible to verify the following two scenarios, with different aspects and complementary ones, considered for ascertaining the result:

- 1 – When company "A" won without having the lowest prices, which companies were disqualified?
- 2 - When the company "B" was disqualified, which companies were the winners?

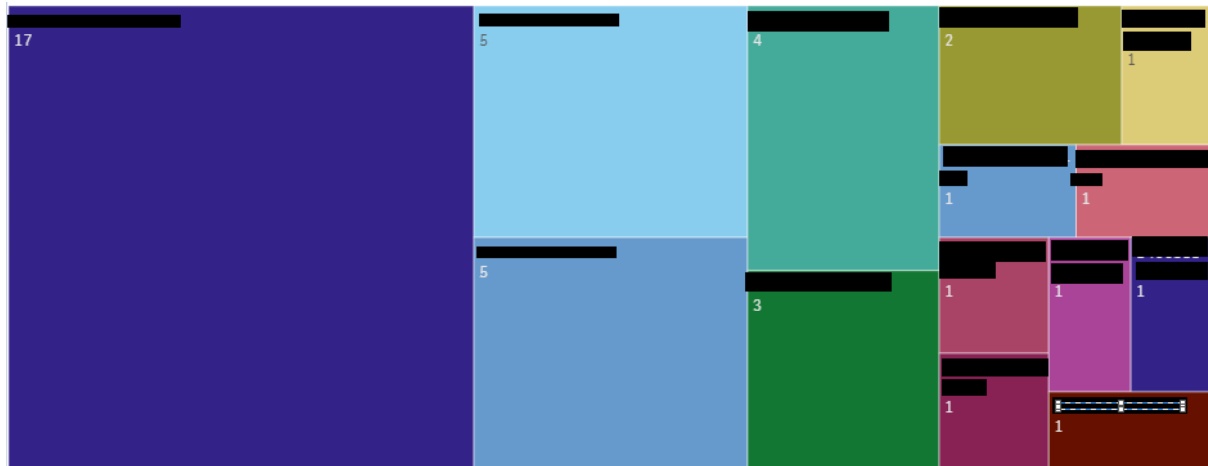


Figure 8: Ex. Given the declassification of a supplier, which companies got the right to sell?

### EVALUATE THE IMPACT BY USING BOTS FOR AUTOMATIC BIDS IN ELECTRONIC REVERSE AUCTION

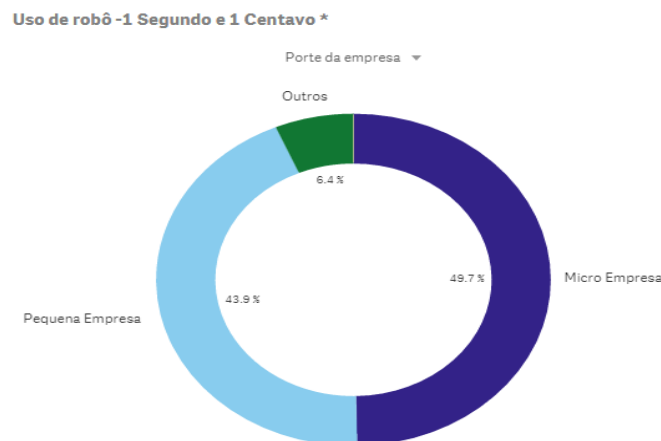
To evaluate the impact of the use of bots in the electronic previews, a database with more than 13 million records containing indicators was built to support the results presented.

The use of bots was more actively perceived in the random phase, in which the winners of the electronic reverse auctions are defined. At this stage, 72.45% of the bids are concentrated.

It is reasonable to infer about the greater importance of bots at this stage, since randomness in defining their duration makes the speed and capacity to cover a bid an even more strategic factor. In this stage is where the "real" competition for the object/item bid occurs.

Regarding this theme, there is a discussion, about the current three phases model. Considering that the definition, in fact, occurs in the last phase and it concentrates the large amount of the bids, we can ask if it's necessary to have two previous phases? Is it not just an inefficient bidding process?

A relevant discussion regarding the use of bots is to understand the profiles of suppliers that use such an instrument. A first thesis points out that hiring bots could be costly for companies, creating an even greater obstacle to micro and small businesses. For this purpose, the following distribution was verified:



\* O conjunto de dados contém valores negativos ou iguais a zero que não podem ser mostrados.

**Figure 9:** Use of bots according to company size

Considering automatic bids from bots those with temporal difference from the previous bid of 1 second and monetary difference of 1 "centavo" (the minimum possible variation), note that 93% of the users of bots are micro and small businesses. Such distribution, in theory, goes against the idea that the use of bots may disadvantage companies with these characteristics.

However, the analysis performed has a restricted behavior and we can consider, in this first analysis, a simple and easily verified bot given the well-defined and aggressive behavior. Obviously, smarter solutions that aim to circumvent the system seek to mask its behavior, having a differentiated variation of their time intervals and variation in each bid.

Another point of discussion that arises is related to the branch of activity of the suppliers that most use bots in the electronic reverse auction. This is a strategic analysis for Public Administration, since its identification can contribute to identify patterns and, therefore, adapt the process if necessary.

Reverse auction with simplified objects inserted in the retail and wholesale trade correspond to 62.4% of the processes in which bots are used.

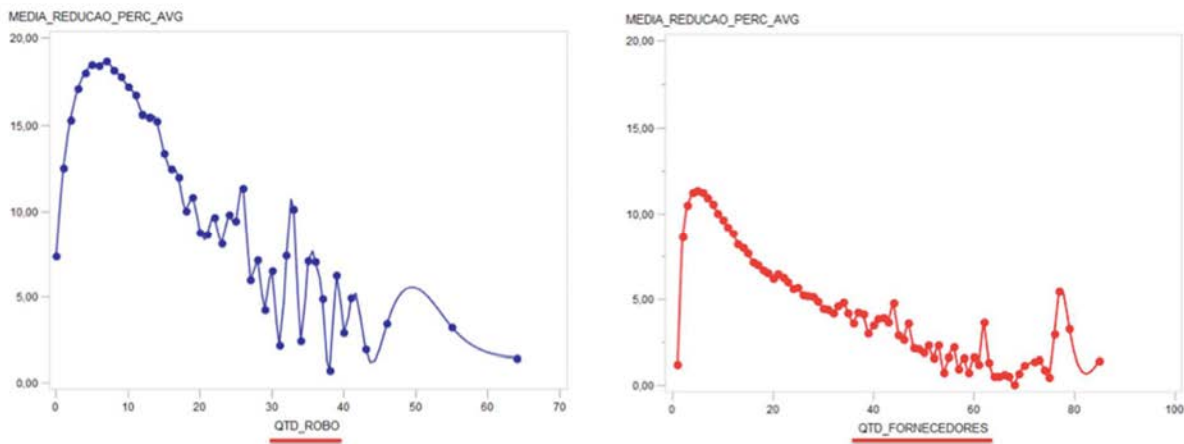
Usage generally takes place in sessions where the object / item is standardized and with a low level of complexity, which is independent of more judicious analyzes and more complex assessments of costs and profits for the definition of bids.

This feature is important for a company that participates in many processes. Making automatic bids decreases the cost with employees to participate on reverse auctions. This is a thesis that reinforces the use by micro and small companies, since the cost with personnel can be extremely high to bid on several simultaneous trading sessions.

Another point of analysis and discussion is related to the ranges of values in which bots are more frequently. About 44% of the bids given by bots are for items in the range of R\$ 1.000,00 to R\$ 10.000,00, and 32% for items in the range of R\$ 0,01 to R\$ 1.000,00. Once again reinforcing the concept of using bots in basic and less complex items that are available to micro and small businesses.

The economics of the process are fundamental. One of the purposes of this study is to answer the question about the way in which the use of bots is associated with the most advantageous proposal for public administration, considering the lower price criteria.

To analyze this issue, we compare the lowest price presented when the random phase starts with the final price presented by the bidder, calculating the average discount for a given number of suppliers presenting bids manually and those that use bots, as shown in the following graphs:



**Figure 10:** Average discount obtained per bot quantity in the process and quantity of suppliers

The graphs show that to get the lowest price, having an optimum number of bots can be more efficient than simply increasing the competition in terms of the number of suppliers.

This analysis consolidates a dichotomy for the Public Administration. Watch over for isonomy by blocking the use of bots and paying higher values in processes or jeopardizing isonomy and paying a lower price.

Thus, it is important to analyze the use of bots and the number of participants involved in a joint manner, not only on economics, but also on the perspective of this dichotomy.

The figure below lists the number of participants in an electronic reverse auction with the number of bots used in the process. It should be noted that the analysis in question did not consider a minimum sample space in its computation.

Cruzamento de #Robôs vs #Fornecedores (Redução de preço do Aleatório até o preço final)

TOTAL_USO_ROBO	TOTAL_FORNEC...																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
0	0,04	6,89	9,73	9,54	8,68	7,93	7,80	6,62	5,91	5,48	4,85	5,35	4,11	4,87	4,97	5,15	4,04	5,85	5,19
1	7,79	15,39	16,72	16,12	14,54	12,92	11,49	10,12	8,89	8,07	7,00	6,85	5,68	5,68	5,60	5,33	4,67	5,90	4,59
2	-	19,00	21,92	21,17	19,78	18,07	15,93	14,24	12,64	11,32	9,64	9,14	7,41	7,26	6,94	6,59	6,44	6,10	5,33
3	-	-	21,88	23,89	23,41	21,54	20,19	17,96	15,97	14,26	12,80	11,36	9,85	9,40	8,11	7,79	6,79	6,86	6,59
4	-	-	-	25,00	25,47	24,41	22,57	20,99	18,80	17,62	15,13	14,20	11,71	10,58	10,02	8,98	7,95	8,72	7,90
5	-	-	-	-	26,66	26,82	24,86	23,94	21,77	19,37	17,58	15,89	13,89	12,90	12,00	10,84	9,41	10,23	7,22
6	-	-	-	-	-	28,34	27,10	25,40	23,49	21,60	20,32	18,76	16,13	14,37	12,93	11,51	10,60	11,18	9,93
7	-	-	-	-	-	-	28,84	29,33	26,65	24,40	22,08	20,42	18,03	16,65	15,13	14,08	11,80	12,19	9,72
8	-	-	-	-	-	-	-	30,38	29,04	26,66	24,75	22,17	20,60	17,99	17,05	14,30	13,12	12,78	11,92
9	-	-	-	-	-	-	-	-	29,27	28,97	26,69	25,46	22,71	19,76	18,79	15,85	14,73	14,66	12,67
10	-	-	-	-	-	-	-	-	-	33,64	28,39	25,45	24,08	23,87	19,50	17,91	16,95	14,50	12,64
11	-	-	-	-	-	-	-	-	-	-	25,86	27,70	25,77	25,55	21,30	18,97	19,63	17,96	13,89
12	-	-	-	-	-	-	-	-	-	-	-	32,26	28,31	27,87	24,22	20,64	18,33	14,84	14,57
13	-	-	-	-	-	-	-	-	-	-	-	-	29,79	32,60	28,56	22,52	21,56	18,18	12,84
14	-	-	-	-	-	-	-	-	-	-	-	-	-	46,55	31,10	22,56	20,10	20,44	20,25
15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	36,76	28,23	22,49	19,25	19,92
16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	48,31	33,87	15,72	17,87
17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	28,13	24,69	24,21
18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	21,81	8,18
19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

**Figure 11:** Crossing information about bots by suppliers and reducing price from random to final price. X axis – Number of bots; Y axis – Number of suppliers; Cell value represents the percentage of discount.

The absence of bots, indicated by the first line, reduces the rates of economicity of a bidding process (when the bot was not used at any time). Likewise, when there is little or no isonomy in the process (just a few bots), there is little or no economic benefit to the Administration. In this condition, those processes are understood when less than 50% made use of bots.

It is important to emphasize that the concept of isonomy seeks to maintain equal conditions. If most or all suppliers use the same resource, it can be considered an isonomic process or very close to it.

Such behavior leads us to observe the diagonal of the matrix presented. Note that the biggest discounts are offered in processes where all or most of the suppliers used bots, and there is no disproportionate violation of the principle of isonomy.

Prices, on lower average, can be explained not only by the presence or the high number of bots, but also by the full use of this tool.

Apparently, the effect of the bots on the bids is not negative. However, more robust analyzes are needed to prove this hypothesis.

Data demonstrate the importance of the topic in aiming the lowest price and widen the debate by demonstrating that the use of bots by all participants is certainly linked to lower prices than those found when only a few uses.

So, the state's effort and action must be to create mechanisms for blocking or mitigating the use of robots or would it be the case of thinking about the institutionalization of robots and simplification of bidding procedures?

## CONCLUSION

Aiming to build audit trails with the purpose of preventing fraud and conducting behavioral studies to optimize the institutional processes, several analyzes was carried out based on electronic reverse auction data from SIASG, a system that centralizes most of the public procurement processes on federal level in Brazil.

The analyzes allow to identify the occurrence of three central behaviors for the discussions of improvements of processes and public procurement systems in the country. The first considers improper use of benefits by micro-companies and small businesses, a behavior that occurs in hundreds of suppliers that fall under

the terms of misuse, related to a few thousand items of purchase and hundreds of millions of reais in the period.

These large numbers illustrate the importance of the problem and the identification of cases makes it possible to carry out corrective and compensatory actions in an educational bias. In addition, it reinforces the importance of integrating government bases with solid and reliable data that allow a more efficient calculation in the procurement processes, as well as guaranteeing the efficiency and effectiveness of public policy aimed at micro companies and small businesses.

The identification of "rabbits" and possible collusions, the trail presented in the sequence, allows for the improvement of systems and the revision of standards to curb this practice. Identifying the companies that perform this practice makes possible several actions, among them, the prioritization of companies for audit processes and consequently block their participation in future bids.

In addition, it seeks to institute preventive ways of identifying and improving the model by crossing other bases and information such as partners and managers, physical and logical addresses (Internet address - IP), models of proposals for mere formalization of participation, among others

Finally, the evaluation of the impact of the use of bots demonstrates the importance of such theme in the public procurement scenario and the relationship between the use of this tool and lower prices. However, the effect of such use may be even greater when all participants use this artifice. The consideration of new perspectives of solutions for the suppliers adds value to the public purchases processes in Brazil aiming the simplification of processes using technological resources.

The improvement of the systems against undue behavior by the participants in the electronic reverse auctions gains strength from the analyzes contained herein. In addition to identifying cases of fraud and guiding the improvement actions based on the behaviors visualized, the analyzes also generated an important informational framework for the creation of a mechanism to optimize the processes in search to guarantee the most advantageous proposal.

Some steps need more detail and are challenges for the improvement of the results found in this study, among them the need to define a more robust way for the identification patterns of using bots and the statistical analysis to evaluate the impact of its use.

The studies demonstrate the importance of not only storing data and records, but rather evaluating the information contained and extracting value for continuous improvement of models and processes. This has been the initiative of the Brazilian Government in the theme of Public Procurement.

Finally, it is important to highlight the suitability of the methodologies and tools available in the solution to meet the proposed objectives.

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## **CONTACT INFORMATION**

Your comments and questions are valued and encouraged. Contact the author at:

André Henrique dos Santos Castro  
Ministry of Planning, Development and Management - Brazil  
andre.castro@planejamento.gov.br