Paper 2573-2018

SAS® Fraud Framework and MCMC in Government Estimation of Improper Payments of Social Benefits

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ABSTRACT

Brazil's Social Security monthly budget is about US$12 billion, paying benefits to 34 million people. In Brazil, the Federal Court of Accounts is responsible for auditing these expenses. In the last few years, the Tribunal de Contas da União (TCU) has found several improper payments, and has acted alongside the Social Security Agency to reduce such losses. In this paper, we describe how SAS® Fraud Framework was used to estimate and monitor the evolution of the percentage of improper payments of social benefits granted. The TCU team conducted 685 interviews with experts from different areas (auditing or control). Based on the analysis of this data, they generated triangular probability distribution per respondent, applied Markov chain Monte Carlo (MCMC) simulations and fitted probability distributions (Kernel and Beta), aiming to estimate the incidence of irregularities. The reliability level of the instrument was verified by cluster analysis and by the use of retest items in the interviews. The results showed that 20% to 38% is the expected percentage of improper payments in Brazilian Social Security, according to the perception of experts regarding the incidence of all possible types of irregularities. Analyzing by type of benefit or region, the Northern Region and the benefits to the poor elderly showed the highest averages (29% and 27%). These procedures resulted in the estimation of approximately $18 million improper monthly payments.

INTRODUCTION

Identifying improper payments is usually a task of an institution’s internal audit, which can deter them by enhancing the internal controls or by cancelling fraudulent benefits. This is generally made individually, what makes it difficult to determine the institution overall rate of improper payments.

In the public sector, some Supreme Audit Institutions have chosen to apply data analytics to have better estimation of this rate or to identify groups of benefits that share characteristics that point to a possible fraudulent nature. In March 2017, the US Government Accountability Office (GAO) released a report that highlighted their use of data analytics to address fraud and improper payments (GAO, 2017).

The British Department for Work & Pensions conducted a different approach, published at November 2017 by the title of *Fraud and Error in the Benefit System* (DWP, 2017). They estimated overpayments and underpayments after analyzing random samples of benefits or groups of benefits.

Another important initiative related to the present work is the Corruption perception index, conducted by the Transparency International. They rank 180 countries and territories based on the perceived level of public sector corruption according to experts and businesspeople. Since corruption is an object of complex and difficult measurability, the perceived levels of experts is a trusted proxy to guide interested actors from private or public sectors.

In the present paper, we decided to apply a methodology to estimate a perception index to the improper payments of social benefits. This decision was made because fraud events are relatively rare and that the traditional method of compliance audit is not capable of identifying every case of fraud or error of public policies, or, when possible, it is too expensive or complex.

Some other identified risks, specific to the public policies studied, identified are the high occurrence of missing information in public processes and databases, the use of counterfeit documents and the existence of criminal organizations that act on the systems’ flaws and fragilities.

These risks can be mitigated by the sharing of the personal experience of analysts, auditors and other experts from different public units, such as the initiative brought by this paper.

METHODOLOGY

The first step in estimating the rate of improper payments of social benefits was to set the scope of benefits to be analyzed. Even though the Brazilian Social Security Agency makes payments associated to 96 different species of social benefits, the species can be summarized in nine groups:

1. Retirement due to age – rural worker.
2. Retirement due to age – urban worker.
3. Disability retirement.
4. Retirement due to contribution time.
5. Illness aid.
6. Social security benefit for people with disability.
7. Social security benefit for the elderly.
8. Pension due to death.
9. Other benefits.

The ninth group was left out of the scope of the work, because of the heterogeneity of these benefits, which would hinder the process of estimating the level of payment impropriety.

After defining the scope of benefits, it was necessary to choose which experts should answer the survey. There were three groups of experts: the operational supervising team of the Brazilian Social Security Agency (who are responsible for reviewing and cancelling benefits with signs of impropriety); the internal audit team (central unit that oversees audit); and the pensions special task force (experts on risk and intelligence, who work routinely with members of the Federal Police and federal prosecutors). These groups consisted of 690, 76 and 117 experts, respectively, adding up to a total of 1.146 people and will be referred to Experts 1, 2 and 3 throughout this paper.

After defining the scope and universe of survey respondents, we followed the workflow described in Figure 1**Erro! Fonte de referência não encontrada.**.

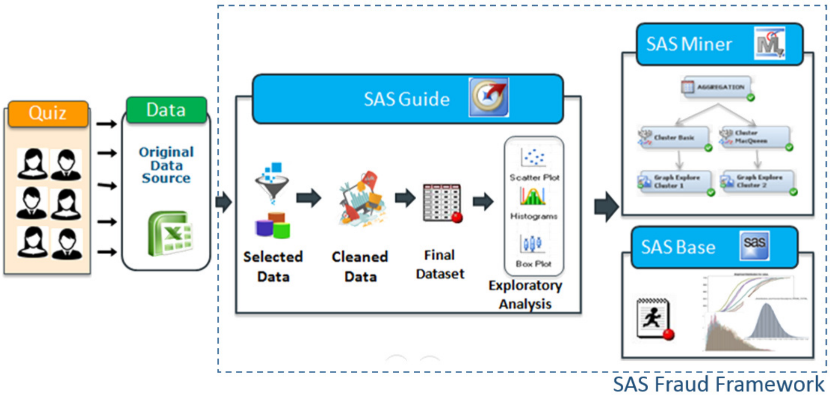

Figure 1. Data analysis workflow

The questionnaire was designed using Limesurvey, a free and open source survey and statistical app. For each one of the eight selected benefit groups, there were three questions about the experts' perception of improper payment rate: the minimum, maximum and most likely rate of benefits payed with error or fraud. In addition, there were four retest questions to evaluate the consistency and quality of the data. A link to the survey was sent by e-mail to all possible respondents, considering the low cost of conducting a survey by e-mail and the possibility of significant non-response.

All the collected data were compiled, prepared and analyzed using SAS Fraud Framework modules. After the collecting period, the original data were imported into SAS Enterprise Guide, where the data preparation phase was conducted. At first, the data were cleaned, in order to prevent the use of low quality inputs, such as answers falling outside the range (0% to 100%) or incoherent information (minimum exceeding the most likely or maximum, maximum lower than minimum, most likely outside the minimum-maximum range). We also checked the coherency of the retest questions, for each respondent. The answers were weighted according to the size of each group of respondents with the purpose of balancing their influence, each contributing with one third of the final model. There was also a regional weight in the model, in order to maintain the proportion of benefits payed in each of the 27 Brazilian federal states (including the Federal District). The project team analyzed the data by using the Descriptive and Exploratory Analysis tools available in SAS Enterprise Guide

The project team used SAS Enterprise Miner to conduct more sophisticated analysis, for example, an unsupervised cluster analysis to identify respondent groups with similar opinions based on their answers.

The last part of the work consisted of developing an estimate of the improper payment rate of social benefits. To determine this rate, each respondent's information resulted in eight triangular probability distributions, one for each group, composed by the minimum, most likely and maximum rates informed. These distributions, weighted by the respondent's region and unit of origin, integrated a Markov Chain Monte Carlo model, which would have intermediate outputs of improper payment rates by region, unit of origin and group of benefit and a final output of a general improper payment rate. This was executed with the support of SAS Base routines.

RESULTS

QUESTIONNAIRE AND DATA PREPARATION

The three units of experts had similar and high percentages of valid answers: 540 respondents of Experts 1 (78.3% of 690 experts), 55 respondents of Experts 2 (61.1% of 76 experts) and 90 respondents of Experts 3 (76.9% of 117 experts). This rate of return was considered acceptable, when considering that missing data could in part be due to holiday, sickness or other leaves. The total number of individual who responded the survey was equal to 685 individuals.

The preliminary descriptive analysis of the data indicated that Social Assistance benefits (for people with disabilities, in lime, or for the elderly, in light blue) and rural benefits (in blue) had higher improper payment rates than urban benefits (in red) and pensions due to death (in pink). Figure 2 illustrated the minimum (to the left) and maximum (to the right) perceived rates of improper and fraudulent payments for each group of benefit (the groups of benefit are in the same order as listed above).

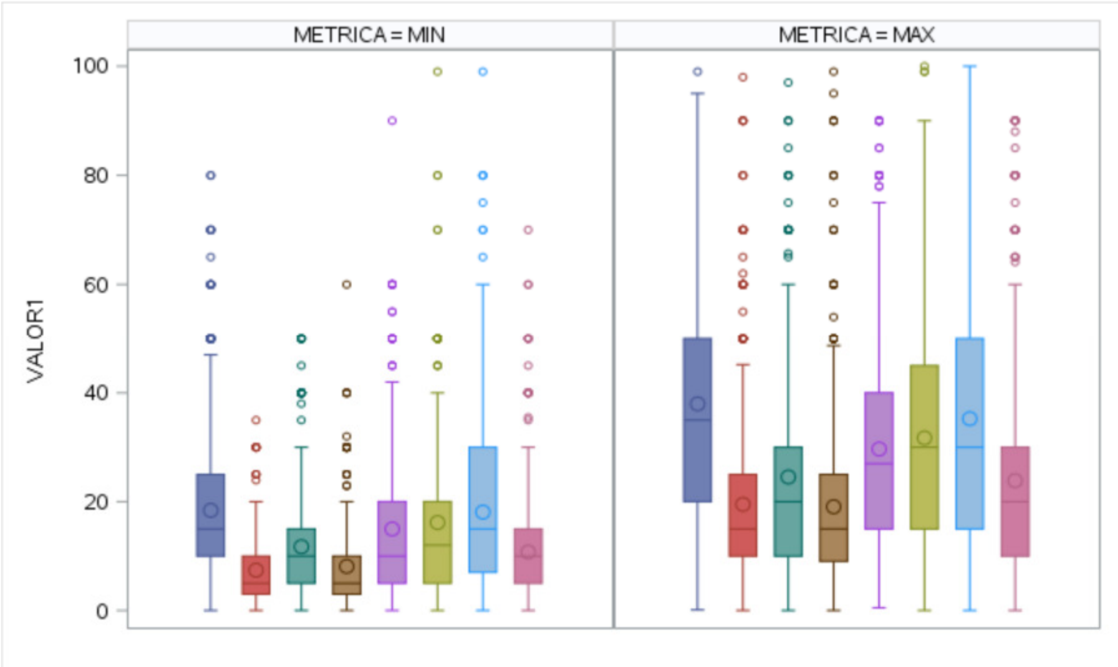

Figure 2. Minimum and maximum perceived rates distribution by group of benefits

This same analysis was applied to minimum and maximum answers given by each of the three groups of experts, as seen in Figure 3 and Figure 4 ('MOB', 'AUDITORIA' and 'APEGR' are the Portuguese terms for 'operational supervising team', 'internal audit team' and 'pensions special task force'), showing that the premise of considering the units as homogenous is valid.

When applying to the Brazilian regions (Brazil is divided into five geographical regions: North, Northeast, Center-West, Southeast and South, each with distinct social and economic characteristics), the similarity of the units was maintained, although there was no homogeneity between regions. This justifies estimating intermediary rates by region and by group of benefits, but not intermediary rates by unit of experts.

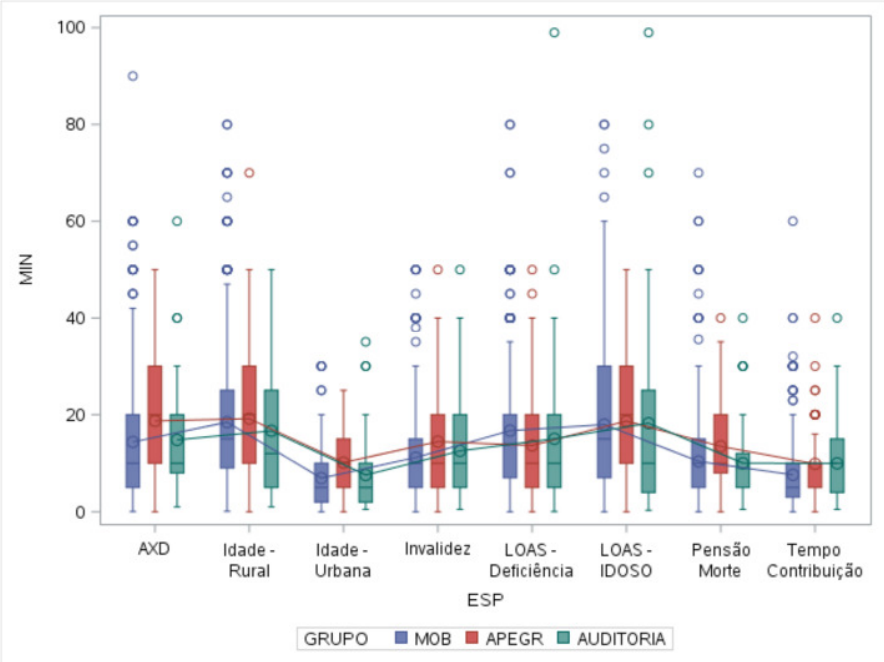

Figure 3. Minimum perceived rates distribution by group of experts group of benefits

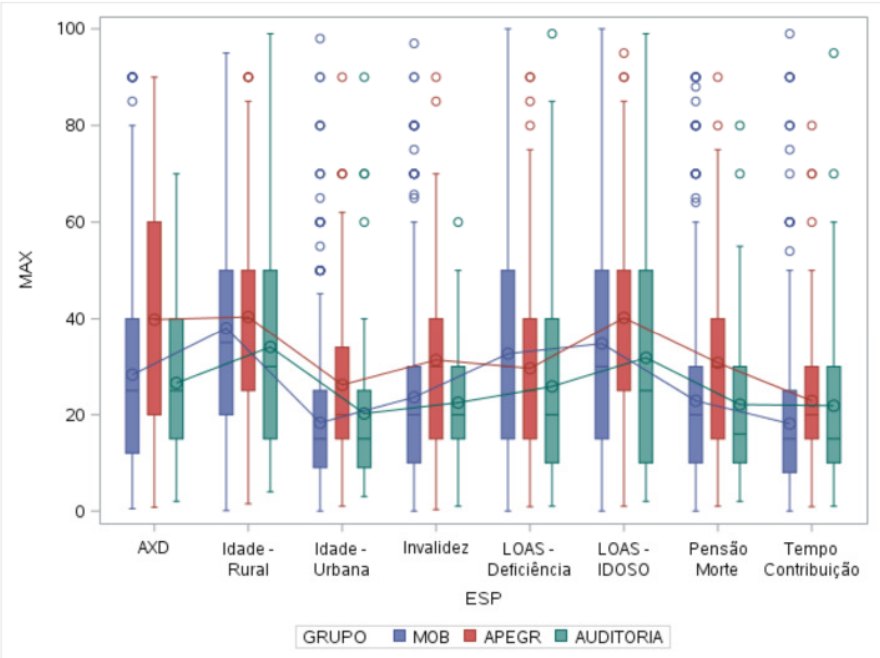

Figure 4. Maximum perceived rates distribution by group of experts and group of benefits

Allied to the Boxplot analysis, the cluster analysis also pointed to a certain similarity amongst the three groups of experts. The method chosen was a Centroid technique, as a non-hierarchical cluster analysis to identify how many clusters would better divide the observations.

Using a dendogram analysis and the measures R-squared, Pseudo T2, Pseudo F and Comparison of CCC there were six eligible distinct partitions in the analyzed data, which had no apparent correlation to the expert’s unit or region of operation. The dendogram is showed in Figure 5, as an example.

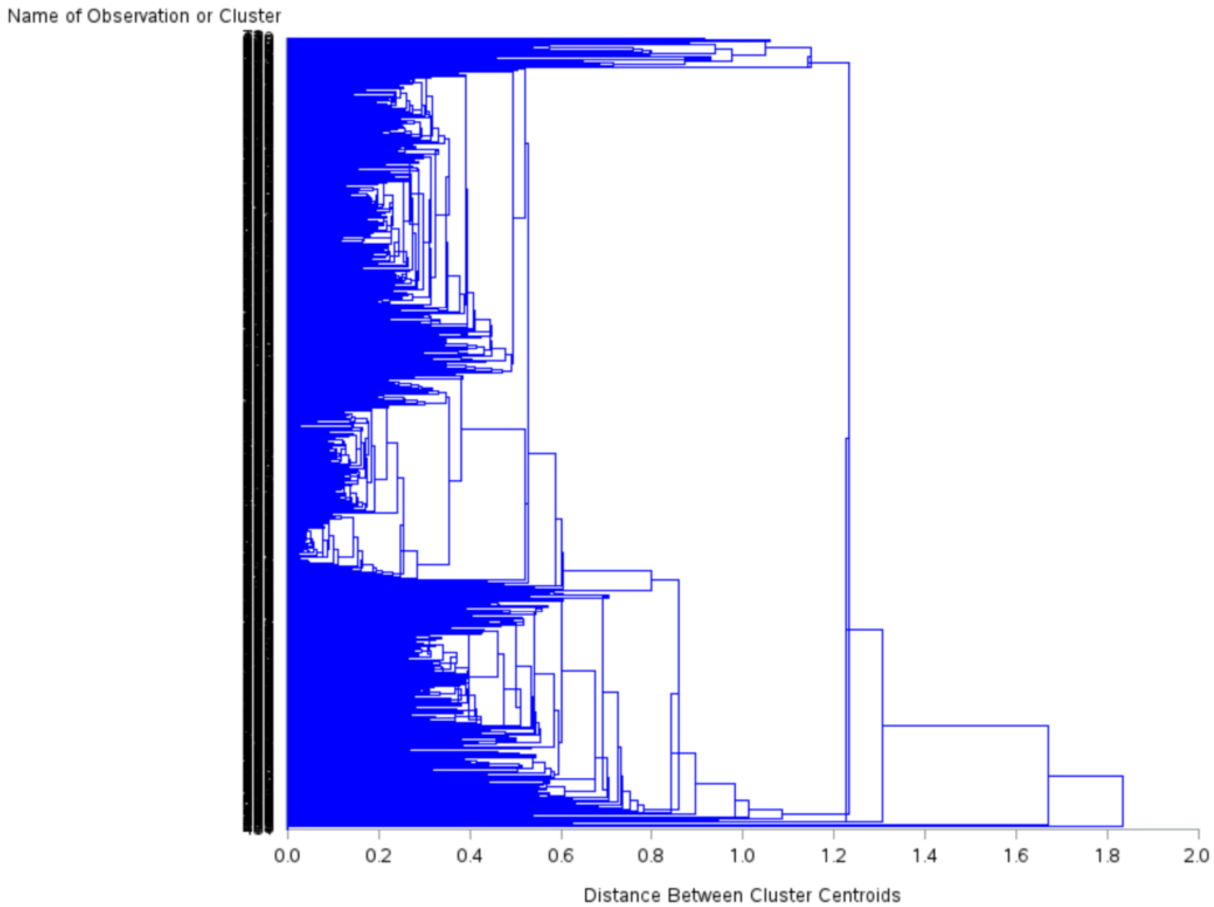

Figure 5. Dendogram with cluster centroids information

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After ensuring that the data generated by the three units of experts were similar enough to allow a single estimated rate, data stemming from all respondents were analyzed with the use of a Markov Chain Monte Carlo method.

Each respondent's triangular probability distributions were sampled a certain number of times to balance the final output in accordance to the total number of benefits, as illustrated in Tables 1 and 2. Table 3Table 3. Number of samples per region per unit of experts has a cross analysis of these two tables, resulting in the number of samples per unit per region.

Experts	# of respondents	# of simulations	Total of simulations
Experts 1	540	1,000	540,000
Experts 2	90	6,000	540,000
Experts 3	55	9,818	540,000
Total	**685**		

Table 1. Balancing the number of samples per group

Region	Number of benefits	%	Experts 1	Experts 2	Experts 3
North	1,804,167	5.3 %	24,094	24,094	24,094
Northeast	9,224,711	27.3 %	123,194	123,194	123,194
Center-West	1,898,909	5.6 %	25,359	25,359	25,359
Southeast	14,817,660	43.9 %	197,886	197,886	197,886
South	5,950,474	17.6 %	79,467	79,467	79,467
Brazil	-	-	90,000	90,000	90,000
Others (group 9)	59,921				
Total	**33,755,842**	**100 %**	**540,000**	**540,000**	**540,000**

Table 2. Balancing the number of samples per region

Region	Experts 1	Experts 2	Experts 3
North	2,677	6,024	4,016
Northeast	4,563	30,798	438
Center-West	4,227	2,536	25,359
Southeast	9,894	14,135	1,622
South	7,947	8,830	803
Brazil	5,000	6,429	2,903
Total	**34,308**	**68,752**	**35,141**

Table 3. Number of samples per region per unit of experts

For every group of benefits, the sum of all the samples resulted in a consolidated histogram, such as the one in Figure 6, for the species of benefit ‘Pensions due to death’.

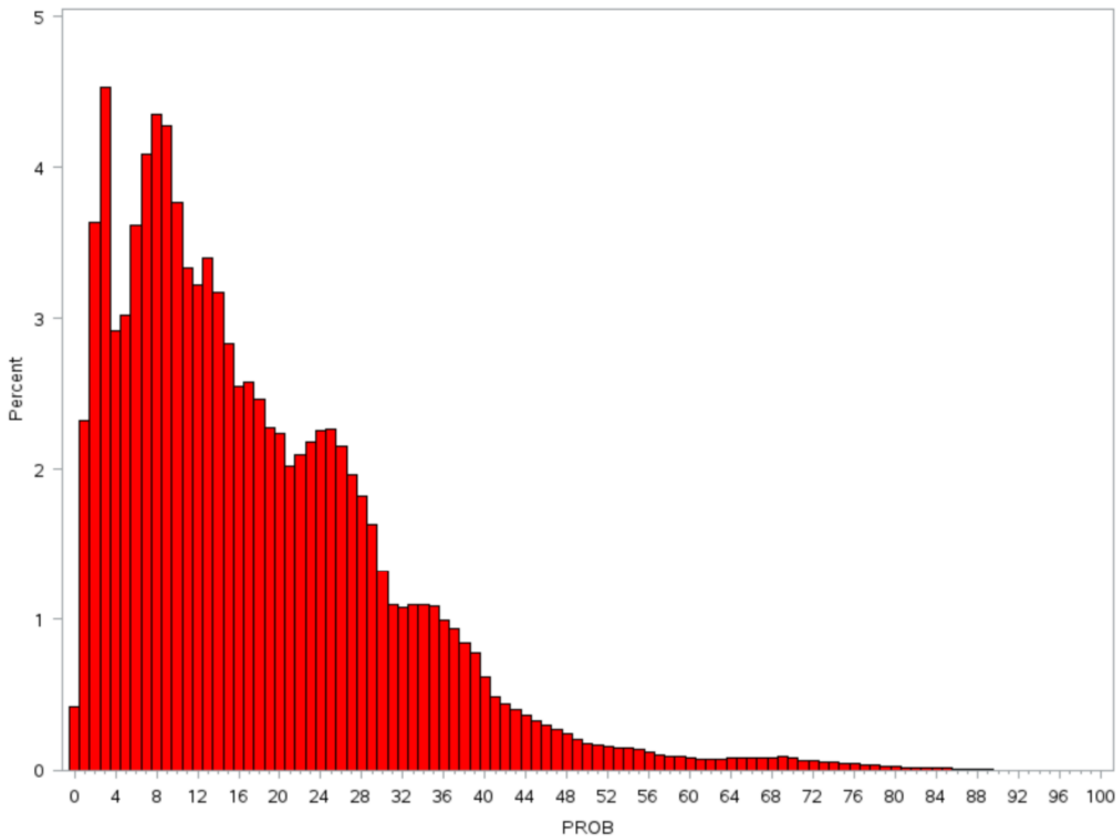

Figure 6. Histogram for consolidated perception of improper payment rate for Pension due to death

The following step of analysis was to verify the adherence of these data to the Beta, Beta per group and Kernel curves identified by the team, using the Kolmogorov-Smirnov test. Results indicated the adoption of the Kernel for the final MCMC simulation.

The MCMC model had as inputs the amounts of benefits for each of the eight groups of benefits and the respective kernel curves. These inputs generated 1,000,000 samples, which led to the final estimation for the improper payment rate and probability distribution, illustrated in Figure 7 and detailed in Table 4. Measures of the MCMC output for the eight groups of benefits.

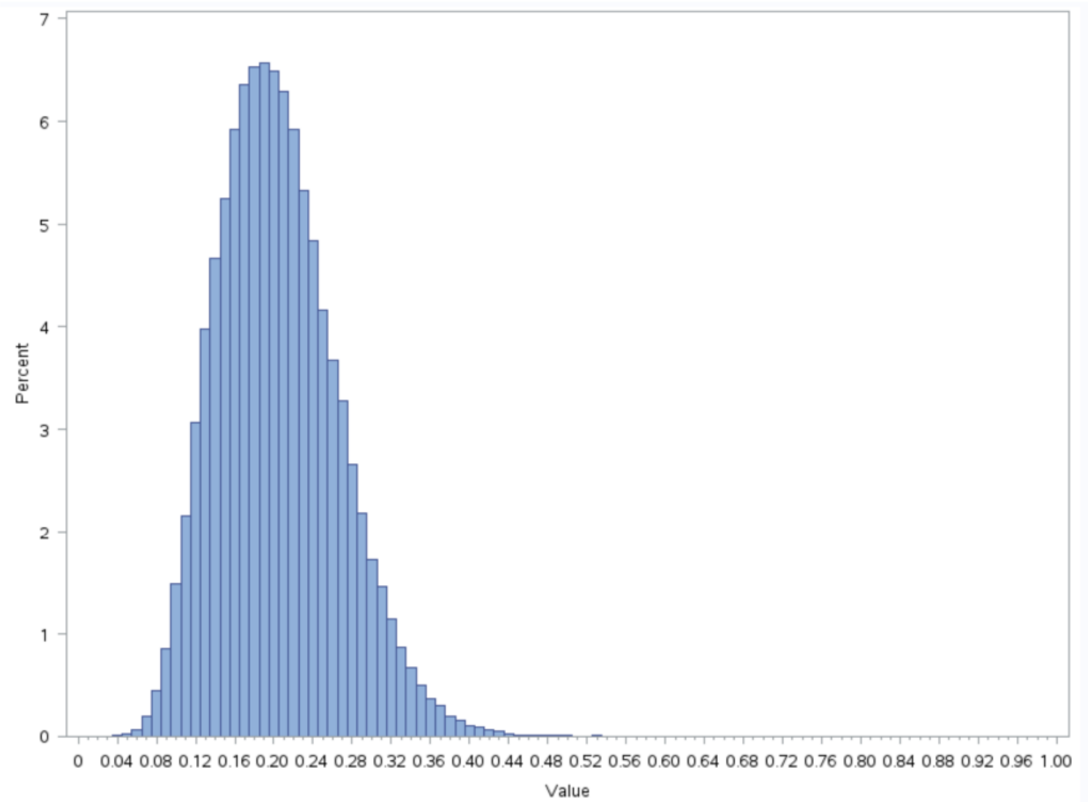

Figure 7. Histogram for consolidated perception of improper payment rate for all analyzed benefits

Measure	Value
Minimum	4.02 %
Maximum	52.46 %
Standard deviation	6.03 %
5% Percentil	11.43 %
Median	19.89 %
95% Percentil	31.10 %
Average	20.38 %
Lower bound (90%)	11.41 %
Upper bound (90%)	31.14 %

Table 4. Measures of the MCMC output for the eight groups of benefits

CONCLUSION

One of the main concerns of the public external control is to verify if the public money is being properly spent. This concern may manifest itself in two different approaches: the regular use and the efficient use, usually the objects of compliance audits and performance audits respectively.

This work gives the public sector decision-makers essential information regarding the overall rate of improper payments of social benefits, through the perception of experts in supervising or auditing social benefits granting and paying.

The results presented here will aid the auditing teams in defining which groups of benefits should be focused and even which of them might be re-discussed by the Congress, which is the case of rural benefits, the group with the highest rate of perceived impropriety.

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