

# Use of newcomb-benford law: a contribution to accounting compliance audit in the federal network of professional and technological education

Jailson Oliveira da Silva , Diego Rodrigues Boente 

Fucape Business School, Espírito Santo, Vitória, Brazil.



<sup>1</sup>jos\_imp@hotmail.com

<sup>2</sup>diegorodrigues@fucape.br

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## Abstract

**Objective:** This study aims to analyze the accounting compliance of budgetary and property expenses of the Federal Network of Professional and Technological Education, using the methodology of the Newcomb-Benford Law.

**Method:** A descriptive study was carried out with a quantitative approach, using the z, chi-square and Mean Absolute Deviations tests, using secondary data on budgetary and property expenditures from 42 institutions that make up the Federal Network of Professional and Technological Education. The collected data from 2017 to 2020 was extracted using the Treasury Management system.

**Results/Discussion:** The results showed that there was a trend of growing compliance of consolidated budget data in relation to the Newcomb-Benford Law in the period from 2017 to 2019, pointing to a possible improvement in the quality of accounting information over these years. However, it is possible to observe distortions in the analyzed values, which may be associated with errors, fraud or particular characteristics of the entities' transactions. The results point to the possibility of using the Newcomb-Benford Law as an important technique in audit work in the Federal Network of Professional and Technological Education.

**Contributions:** Considering that the Brazilian public sector lacks data integration, the study advances in the discussion on the use of the Newcomb-Benford Law as an accounting compliance audit tool, contributing to audit planning and asset control and budget execution. In addition, the signaling of distortions in accounting data (red flags) are risk indicators and can demonstrate a situation of irregularity in real time.

**Keywords:** Audit; Newcomb-Benford Law; Federal Education Network; Public sector.

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## Introduction

**P**ublic institutions have been increasingly pressured to make the best possible use of public money. This fact is a reflection of greater social control, allowed by the advancement of technology and greater dissemination of information (Pederneiras et al., 2018). Legislation such as the Fiscal Responsibility Law, the Access to Information Law and the recent requirement for accountability of federal public sector institutions in the integrated reporting model have contributed to the strengthening of this control and greater accountability in the use of public resources (Ganassin et al., 2018; Iacuzzi et al., 2020).

However, due to the limited workforce available in the bodies that exercise this control, it is important to use the most efficient inspection instruments possible, which allow directing analyzes to statements or transactions that may have a greater probability of error or fraud (Vieira, 2014). According to Ferrero et al. (2015), a technique that allows saving time and channeling audit actions to these transactions is the Newcomb-Benford Law (NBL), derived from the seminal studies of Newcomb (1881) and Benford (1938). This technique facilitates the work of auditors by pointing out groups of expenses that deviate from the expected pattern, and may contain errors or fraud. This reduces the sample to be analyzed, resulting in more efficiency in audit work (Ribeiro & Monsueto, 2015).

The studies by Silva et al. (2017), Ribeiro and Monsueto (2015), Cunha (2013), Geyer et al. (2017), Oliveira, Milani Filho et al. (2018), Costa et al. (2012), Cunha and Bugarin (2015), Badal-Valero et al. (2018) investigated the application of this law in the area of finance and government auditing in some institutions, relating non-compliance with the NBL with evidence of irregularities in financial transactions and financial statements. Other studies have linked compliance with the NBL with the highest level of transparency of municipalities, better corporate governance structure of companies and lower level of earnings management (Al-Rawashdeh, 2017; Cella & Zanolla, 2018; Limeira et al., 2020). Thus, it is important to broaden the debate on the subject, since discussions on the applicability of the NBL in the public sector are still incipient.

Thus, this study aims to analyze the accounting compliance of budget and property expenses of the Federal Network of Professional and Technological Education (RFEPT), using the NBL methodology.

Thus, the present study is justified from a theoretical

perspective by adding results to the discussions on the applicability of the NBL, specifically in the public sector, in which there is a need for strict control of the large volume of public resources moved (Orth et al., 2020). It is also expected to improve the understanding of the subject, through the integration between theory and reality demonstrated by the obtained data; contributing to the literature focused on the detection of accounting and financial fraud in the public sector.

From a practical perspective, it is justified by presenting information that can support the planning of accounting compliance audit activities within the scope of the analyzed entities, which may be useful for defining audit trails, since the lower compliance with the NBL may show possible elements with errors or fraud. Thus, the internal and external control bodies and the managers themselves can use the instrument to monitor the execution of public expenditures.

It is important to highlight that the study seeks to investigate in two distinct databases, with the aim of strengthening the findings: the paid budgetary expense, recorded from the entity's cash flow outflow (disbursement), and the equity expense, recorded as it incurs, regardless of cash outflow, on an accrual basis.

The research was carried out using secondary, quantitative and longitudinal data from 2017 to 2020, collected through the Gerencial Treasury system. Statistical analyzes were performed using z, chi-square and Mean Absolute Deviations (MDA) tests, using Excel.

## 2. Theoretical Reference

### 2.1 Public accounts audit

The Brazilian Federal Constitution (1988) establishes that control in the Federal Public Administration is carried out in two ways: internal control, carried out by the body itself; and external control, which is carried out by the National Congress with the help of the Federal Audit Court. In addition to these controls, organizations are subject to a third type of monitoring, which is social control. It takes place through popular participation in decisions on public policies and monitoring the execution of public resources (Sabioni et al., 2016).

The internal audit is part of the internal control and has the objective of adding value and improving the operations

of the entities, helping them to reach their organizational objectives. Its actions seek to improve governance processes, optimize risk management and internal controls (Controladoria-Geral da União [CGU], 2017). In addition to the typical functions of evaluation and consultancy, the internal audit is responsible for investigating illegal or irregular facts resulting from fraud or errors in the use of public resources, as provided for in Federal Law No. 10,180/2001. External control, in turn, also has the function of supervising the public resources applied, not limited to aspects of legality, but contemplating the analysis of the efficiency and effectiveness of the actions of public managers (Amorim et al., 2017). Thus, internal and external control actions seek to identify non-compliance in the accounts of the audited institutions, assessing whether the non-compliance is due to errors or fraud (Amorim et al., 2017).

Considering the frequency with which fraud is still observed in the public sector and the risks related to errors that agents may commit in the exercise of their functions, it is increasingly necessary to use instruments and techniques that allow identifying distortions in accounting data. In this way, the NBL presents itself as an important tool in this process, which can be useful to point out red flags, which are indicators that point to a possible occurrence of distortions in the financial statements, being useful for the prevention and detection of fraud (Melo & Santos, 2012; Pereira, 2020). Red flags are understood as risk indicators, which act as warning instruments in the face of possible fraudulent behavior (Nascimento, 2020). These indicators can demonstrate a situation of irregularity happening in real time (Baader & Krcmar, 2018).

## **2.2 Federal Network of Professional and Technological Education**

According to the Ministry of Education (2011), Law 11.892/2008 created the Federal Network of Professional, Scientific and Technological Education, composed of the then Federal Centers of Technological Education (CEFETs), which were renamed Federal Institutes of Education, Science and Technology, CEFET Celso Suckow da Fonseca, Federal Technological University of Paraná-UTFPR, CEFET of Minas Gerais, Colégio Pedro II and Technical Schools associated with Federal Universities. From then on, these institutions were organized in a multicampus structure, with each campus and the Rectory having their respective budget proposals, being able to decide on the application of these resources received (Pacheco, 2020).

Due to the large volume of funds moved by these

institutions, it was necessary to create internal audit units, aiming, among other functions, to monitor the accounting compliance of the execution of these budgets. Thus, through Decree no. 3,591/2000, the Internal Audit Units of the Federal Institutes were created to help the institutions to reach their objectives, avoiding the discontinuity of processes and the waste of public resources (De Aquino et al., 2019).

According to the Manual of Technical Guidelines for the Governmental Internal Audit Activity of the Federal Executive Branch, the types of evaluations carried out by the Audit Units are: financial or accounting statements, conformity or compliance, and Operational or Performance; with a predominance of compliance audits – auditing of tenders, pensions and payment of civil servants, contracts, among others – within the scope of the Federal Institutes (CGU, 2017; De Aquino et al., 2019).

## **2.3 Newcomb-Benford Law**

According to Geyer et al. (2017), the Newcomb-Benford Law was initially developed by Canadian mathematician and astronomer Simon Newcomb (1881). Newcomb (1881) observed a frequency pattern of the first and second digits when related to the consultation of logarithm tables, evidencing his findings according to Table 1; in which there is a greater probability of occurrence of values beginning with smaller digits and a decrease in the frequency of subsequent numbers on a logarithmic scale.

Later, Frank Benford (1938) expanded the application of this mathematical law to various applications, such as population analyses, mortality rates, river lengths, molecular weights, among others (Ribeiro & Monsueto, 2015). Investigations associating the application of the NBL to accounting numbers began with Carslaw (1988), who compared the frequency distribution of the first digit of the net profit account values with the frequency distribution of the first digit of the gross profit account values before taxes on companies listed on the New Zealand Stock Exchange. Since then, several studies have sought to verify the relationship between this mathematical law and accounting statements, both in the public and private sectors (Cunha & Bugarin, 2015).

As mentioned by Ribeiro and Monsueto (2015), when numbers are invented they reflect human choices, losing their natural character and making it more unlikely that these numbers conform to the NBL. It should be noted, however, that non-compliance with the NBL does not necessarily guarantee the occurrence of fraud; it merely

**Table 1** – Probability of occurrence of the first and second digits

Digit	0	1	2	3	4	5	6	7	8	9
1° digit	...	0.301	0.1761	0.1249	0.0969	0.0792	0.0669	0.0580	0.0512	0.0458
2° digit	0.1197	0.1139	0.1088	0.1043	0.1003	0.0967	0.0934	0.0904	0.0876	0.0850

Source: Nascimento et al. (2014) adapted from Newcomb (1881).

points out possible indications. In addition, compliance with the law does not mean that the possibility of fraud having occurred can be ruled out, as fraud can occur in various situations in which there is no record of these events in accounting, making it impracticable to apply the law in these cases (Ferrero et al., 2015; Ribeiro & Monsueto 2015).

The work by Badal-Valero et al. (2018) corroborates this by arguing that several data in the business world follow the NBL and the divergence with the Law is indicative of possible irregularity in the financial statements or in the entity's transactions.

Milani Filho (2013) used this technique to assess the reliability of information on expenses and revenues from philanthropic hospitals in Canada in 2009 and 2010 and found that such data were in compliance with the NBL, through the analysis of the first digit. Garza-Gomez et al. (2015) pointed to the use of rounding up in the second digit of earnings of publicly traded companies in the United States in the period from 1998 to 2011, corroborating the findings of Carslaw (1988).

Druica et al. (2018) used the NBL for Romanian bank data for a period of 16 years and concluded that there are cases of stationary trends in foreign currency accounts, therefore, nonconformity with the NBL. However, the authors warn that the results should be evaluated with caution. Harb et al. (2023) published a study on the Lebanese banking sector, in which fraudulent manipulations were detected in the entities' indicators, through the application of the NBL.

Several works have used the NBL to evaluate public (Bugarin & Cunha 2017; Cella & Zanolla, 2018; Costa et al., 2012; Cunha & Bugarin, 2015; Johnson & Weggenmann, 2013) and private institutions, through the analysis of accounting data and financial aspects of these companies (Oliveira, Francischetti et al., 2018), associating non-compliance with the NBL with possible signs of fraud.

Ribeiro and Monsueto (2015) point out that the NBL is more effective when applied to the transaction level, compared to data from grouped levels. In addition, the individual analysis by institution also influences

the effectiveness of the results, given that the grouped analysis of several entities can cause the data from one to influence the results of the other, losing or offsetting values, thus causing bias in the results (Nigrini, 2012).

Despite this, the use of the NBL for joint analysis of institutions with the same characteristics is relevant, as it can point out systematic behaviors of these institutions, such as the same incentives to manipulate numbers (Nigrini, 2012). In the public sector, for example, there may be splitting costs and maximizing the benefits of purchasing processes at a general level.

Durtschi et al. (2004) summarize the cases in which the NBL is applicable and the situations in which the law is not applicable, as shown in Figure 1:

NBL applicability	Example
Aggregate accounts – synthetic level	Income, expense, asset, liability, etc.
Transaction level data	Payments, expenses, sales.
Large data set	Year transactions
Data involving sequential numbers	Zip codes, invoice numbers, check numbers
Cases where NBL is not applicable	Example
Numbers influenced by human thought	Prices with nines, without rounding; ATM withdrawals
Record with frequently repeated values	Account that receives small number of amounts
Where the transaction is not recorded	Kickbacks, bribes, slush funds, thefts.

Figure 1 – Possibilities of using the NBL

Source: Durtschi et al. (2004).

With regard to the results of applying the NBL, Nigrini (2012) points out that when dealing with data related to payments, the second digit test generally shows an excess of digits 0 and 5, due to rounded values practiced in commercial activity.

Thus, based on the literature, the following research hypotheses are presented:

**H<sub>1</sub>: The RFEPT paid budget expenditure data follows the NBL frequency distribution.**

**H<sub>2</sub>: RFEPT's incurred equity expense data follow the NBL's frequency distribution.**

## 3. Research Methodology

### 3.1 Data sample and treatment

To achieve the research objective, a descriptive study was carried out (Vergara, 2016), with a quantitative approach (Martins & Theóphilo, 2016), using secondary data (Vergara, 2016). Data were collected regarding paid budgetary expenses and property expenses incurred by the 42 institutions that make up the Federal Network of Professional and Technological Education. Among several reasons, these expenses were chosen: (a) for their relevance in the context of the audit of the RFEPT (Tribunal de Contas da União [TCU], 2016); (b) the high sensitivity on performance items where there are weak or non-existent controls at the transaction level (TCU, 2018); and (c) for being a materiality reference most cited in research carried out by Leitão and Dantas (2016).

Data collection was carried out using the Treasury Management system, which allowed the extraction of data after preparing reports with the desired filters. A survey of budgetary expenses paid in the period from 2017 to 2020 was carried out, making it possible to discuss both the relationship between the quality of accounting information and the level of compliance with the NBL, and the identification of distortions that may be associated with errors, fraud or particular characteristics of institutions.

The period chosen is due to the availability of data to maintain the comparison between budgetary expenses paid (from the year 2000) and equity expenses incurred (from 2015). For the purposes of the analysis, it was decided to eliminate the years 2015 and 2016 because they were years of adaptations and adjustments in the accounting routines resulting from the implementation in the chart of accounts, as described in the General Balance of the Union (Secretaria do Tesouro Nacional [STN], 2016).

As for the discussion on the quality of accounting information, it should be noted that from 2018 onwards there was an obligation to render accounts through reporting integrated by the institutions, the progress of the process of convergence to international accounting standards and the growing demand for transparency and accountability by society, reflecting a possible improvement in the quality of accounting information. The year 2020 was the limit of the research, in view of the availability of data at the beginning of the study.

The following filters were used in the Managerial Treasury:

type of expense – 319011 (fixed wages and benefits – civilian personnel); 339030 (consumables), 339036 (other third-party services / individuals), 339039 (other third-party services / legal entities), 339040 (information and communication technology services), 449051 (works and installations) and 449052 (equipment and permanent material). The choice of these data filters at the transaction level is justified, according to Durtschi et al. (2004), as they are susceptible to manipulation of numbers (Nigrini, 2012). In the public sector, for example, expenses may be split and the benefits of purchasing processes maximized. These filters were chosen due to their materiality, representing more than 60% of total RFEPT expenses in the analysis period, according to the Nilo Peçanha Platform (Ministério da Educação [MEC], 2023).

In addition to the budgetary expenses, the equity expenses incurred for the year 2019 were extracted for the purpose of comparing the results between the two types of expenses. For this, in addition to the filters in common with budgetary expenses, it used the following filters in the Managerial Treasury: CCon (Accounting Account) – Group (2): 1 – personnel and charge; and 3 – use of goods, services and consumption of fixed capital (STN, 2021).

### 3.2 Statistical Model

Research has used the Z test, the chi-square test ( $\chi^2$ ) and the MDA test (Mean Absolute Deviations) to verify compliance of the data investigated with the NBL (Costa et al., 2012; Nigrini, 2012; Orth et al., 2020), since these tests are more significant from a statistical point of view and are more practical, making it possible to investigate a greater amount of information (Oliveira, Milani Filho et al., 2018).

The Z test shows the statistical difference between the proportions of two populations, when there is a normal data distribution and the sample is large enough (Nigrini, 2012). For the execution of this test, the significance level of  $\alpha = 0.05$  and critical  $Z = 1.96$  was considered, as suggested by Costa et al. (2012). The test results should indicate whether there is a statistically significant difference between the observed ( $p_o$ ) and expected ( $p_e$ ) relative frequency distributions.

The chi-square test ( $\chi^2$ ), in turn, was used to verify deviations in all digits of the numbers analyzed, by comparing the sum of their values with the established critical value. Therefore, the results of the chi-square test

must demonstrate whether the frequency of the analyzed numbers is in accordance with the expected occurrence according to the NBL and whether this conformity is statistically acceptable.

In line with the study by Costa et al. (2012) a significance level of  $\alpha = 0.05$  was established, 8 degrees of freedom for the first digit and 9 degrees of freedom for the second digit. The critical values of the chi-square test are: 15.507 for the first digit and 16.919 for the second digit. When applied to the first two digits simultaneously, the degree of freedom was considered equal to 89 and a critical value of 112.02 (Costa et al., 2012). This test is more recommended for application in samples smaller than or equal to 500 items (Nigrini, 2012).

Nigrini (2012) suggests the mean absolute deviation test (MDA) for application in more extensive databases, aiming to overcome limitations presented by the chi-square test. Therefore, from 500 items, it is more recommended to use the MDA test.

For the purpose of analyzing the conformity of the investigated data and the NBL, Nigrini (2012) presents the parameters below in order to establish critical values to accept or reject the conformity.

	First Digit	Second Digit	First two digits	Compliance with the NBL
Range	0 a 0.006	0 a 0.008	0 a 0.0012	Compliant
	0.006 a 0.012	0.008 a 0.010	0.0012 a 0.0018	Acceptable
	0.012 a 0.015	0.010 a 0.012	0.0018 a 0.0022	Marginal
	Above 0.015	Above 0.012	Above 0.0022	No compliant

Figure 2 – NBL compliance parameters.  
Source: Adapted from Nigrini (2012).

Nigrini (2012) also developed the sum of the first two digits test in order to detect the materiality of the values corresponding to the sum of the values referring to each pair of digits. This materiality can be due to many repeated transactions (same digit values) or because the values corresponding to each pair of digits have a large representation in the sample. According to the author, each pair of digits must present values that together should represent the same proportion in relation to the total values, that is, for pairs of digits from 10 to 99, the sum of the values of each pair should be 1/90 of the amount.

To apply the test in question, add the values corresponding to each pair of digits, divide this sum by the total value of the analyzed data and finally subtract this ratio from the proportion (1/90 or 0.011), verifying the deviation.

## 4. Results and Discussions

### 4.1 Analysis of paid budget expenses

In this section, the analysis of the results regarding the application of the NBL to the budgetary expenses paid by the RFEPT in the period from 2017 to 2020 is presented. The results are presented considering the budgetary expenses of the management units on a consolidated basis.

Table 2 presents the descriptive statistics of the analyzed values. It is observed that the analyzed budget varies in the range of 9 to 11 billion reais per year. The number of observations of expenses paid totaled 94,322 throughout the analyzed period. The average value of commitments ranged between 354 and 581 thousand reais. The minimum commitment limit was ten reais. This limit allowed the analysis of the first and second digits without any difference in the number of elements analyzed in the two tests.

Table 2 - Descriptive statistics of the paid commitments

Year	Budget	Obs.	Mean	Minimum	Maximum
2017	9.394.260.004,22	26463	354.966,03	10,00	503.922.331,74
2018	9.289.501.123,40	24994	371.669,25	10,00	503.199.129,89
2019	10.711.338.369,33	23638	453.140,64	10,14	524.874.773,42
2020	11.177.234.279,78	19227	581.330,12	10,00	415.613.047,97
Total	40.572.333.776,73	94322			

Source: elaborated by the authors.

#### 4.1.1 RFEPT compliance with NBL per year

Observing the results summarized in Table 3, it is verified that, according to the MDA test, the data, when analyzed in a consolidated form, present values within the range of conformity with the NBL. On the other hand, the chi-square test showed different results, as only the year 2020 showed compliance with the NBL and only for the first digit. Thus, based on the fact that the result presented by the MDA test is more reliable for this sample size than the result of the chi-square test, it is more certain that the consolidated values for the period are in line with the NBL.

The tests applied to the first and first two digits indicate that, in the period from 2017 to 2019, there is greater compliance with the NBL over the years, demonstrating a possible improvement in the quality of accounting information during the period, as the literature highlights that the greater compliance with the NBL is associated with elements such as a higher level of transparency,

Table 3 - Compliance of budgetary expenses by the RFEPT

Year	Budget	Qt.	First Digit		Second Digit		First two digits	
			X <sup>2</sup>	MDA	X <sup>2</sup>	MDA	X <sup>2</sup>	MDA
2017	9.394.260.004,22	26463	168,59	0,0068**	126,34	0,0059**	810,69	0,0012**
2018	9.289.501.123,40	24996	83,19	0,0053**	54,15	0,0033**	427,24	0,0010**
2019	10.711.338.369,33	23755	15,85	0,0022**	79,66	0,0044**	274,51	0,0008**
2020	11.177.234.279,78	19229	12,89*	0,0023**	70,84	0,0051**	269,97	0,0010**

Source: elaborated by the authors.

\*Compliant value; \*\*Acceptable value.

better governance and lower earnings management (Al-Rawashdeh, 2017; Cella & Zanolla, 2018; Limeira et al., 2020). This greater compliance may be related to a series of actions to improve accounting information, for example, the adoption of the Integrated Report (IR) from 2018 onwards, which stimulated actions in the sense that institutions demonstrate their process of generating value for society (Iacuzzi et al., 2020).

According to Iacuzzi et al. (2020) the Integrated Report reflected in greater transparency of these institutions; in addition to promoting structural changes due to the requirement to disclose mandatory elements that are part of the value generation chain, such as governance structures aimed at reducing the risks of its activities.

On the other hand, the tests applied to the second digit inform that this adjustment to the NBL does not happen systematically over the years, as observed in the other tests. For this test, the highest compliance with the NBL was verified in the year 2018. Therefore, the results applied to the second digit reveal an independence behavior in relation to the others.

According to the MDA test, the data for the year 2020, however, show greater distortions in relation to the NBL than the data for 2019. The lower compliance in relation to the previous year (2019) can be explained, in addition to other factors, by the reflection of the COVID-19 pandemic on work routines in institutions. Activities began to be carried out remotely and this new routine may have influenced the quality of accounting information (Castilho & Silva, 2020).

It is also interesting to point out that the government adopted some actions in 2020 in order to make the execution of public resources more flexible, weakening its control and compromising the quality of accounting information in that year, such as, for example, measures to suspend the limit on personnel expenses, in addition

to non-compliance with several targets for fiscal results (Depieri & Ramos, 2021).

After the consolidated analysis of budgetary expenditures and its relationship with the quality of accounting information, the results related to the application of the NBL to detect distortions in the analyzed expenditures and, therefore, its usefulness as an auditing technique. Thus, observing the tests applied to the first digit, as shown in Figure 3, it is initially noticed that, as demonstrated by the MDA test, the analyzed digits, in general, follow the frequency curve established in the NBL; being possible to identify the digits that do not present conformity. According to studies by Cunha and Bugarin (2015), the digits that present distortions in relation to the NBL can point to possible errors in entries or even fraud.

In the years 2017 and 2018, numbers 2 and 7 occur more frequently than expected, indicating that in these years the processes of these institutions related to expenses that start with such amounts should be analyzed in more depth. In the years 2019 and 2020, despite the higher frequency of these digits, this difference is not statistically significant. The literature points out that the excess of digit 7 may be related to avoiding the bidding process, placing expenses within the bidding waiver limit - R\$ 8,000.00 for purchases and services, except engineering (Costa et al., 2012). The excess of digit 2 may be due to some specific characteristic of the transactions of the analyzed entities or discretionary decisions of the managers, requiring a more in-depth analysis to identify the anomaly.

In the period from 2017 to 2019, the digits 5 and 6 are observed less frequently than expected, although the digit 6 did not have a significant difference in 2018. The scarcity of these digits may be associated with the displacement of values for the digit 7, which may be due to the managers decision to maximize bid waiver values, reaching the highest possible value within the legal limit, as mentioned by Costa et al. (2012).



Figure 3: First digit distribution of RFEPT's paid budget expenditures.  
Source: elaborated by the authors.

Thus, in a possible audit of the data in question, it would be interesting to deepen the analysis of expenses with amounts starting with the digits 2 and 7 in order to verify whether payments to creditors were made correctly and whether the purchasing processes obey the real needs of institutions. The analysis should initially focus on the digits in excess to, if necessary, evaluate processes that have values with the first digit in a smaller amount than expected, as the latter are not so significant for auditing purposes, since this distortion is usually a reflection of the excess of other digits (Orth et al., 2020).

The analysis related to the tests applied to the second digit, as shown in Figure 4, allows highlighting that in the analyzed period the digits 0 and 9 occur in a higher frequency than expected. Previous research indicates that the excess of the digit 0 may be related to the behavior of rounding values, either by the inclusion of fictitious values (fraud) or by the acquisition of goods or services whose price formation is carried out randomly, without applying a profit margin directly to costs or expenses.



Figure 4: Distribution of the second digit of RFEPT's paid budget expenditures.

Source: elaborated by the authors.

Therefore, it could represent the acquisition, by the Public Administration, of goods or services that do not obey the real market prices (Costa et al., 2012). The excess of the digit 9 in the second position may also be related to the limit for bidding waiver processes, just below R\$ 8,000.00.

It should be noted that the excess of the digits 0 and 5 in the second position is mentioned in the literature as a result of rounded values practiced in commercial activity (Nigrini, 2012). Thus, the excess of 0 can also be a reflection of the normal transactions of these institutions, being important a more accurate analysis of the values.

Regarding the tests applied to the first two combined digits, it is possible to observe in Figure 5 that the pairs of digits, in general, follow the frequency distribution defined in the NBL, according to the results presented by the MDA test. It is also possible to identify pairs of digits that differ from the expected frequency of the NBL, in line with the z test; directing the analysis of a possible audit to a more specific group of processes to be analyzed. As a differential in relation to the first digit test, the first two digit test allows to further reduce the scope of analysis of processes to be audited.

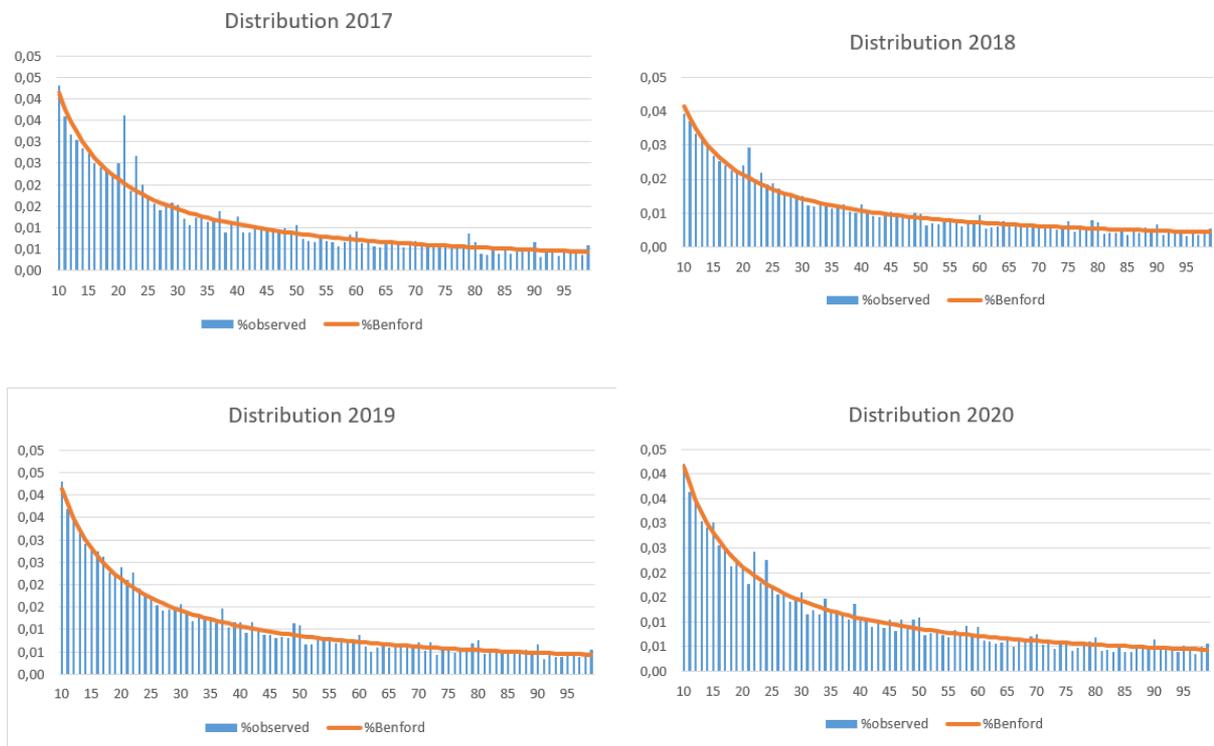


Figure 5: Distribution of the first two digits of RFEPT's paid budget expenditures. Source: elaborated by the authors.

Next, data analysis was carried out using the test of the sum of the first two digits for the year 2019. Said test indicates the materiality that each pair of digits represents in the analyzed sample, being useful for defining audit trails, taking into account the risk (distorted digit) and materiality (sum of the expenses that that pair of digits represents) (Nigrini, 2012). In research already carried out, sum tests have shown, in general, that the tested data do not follow the NBL distribution. The results found follow the same line of previous research, as can be seen in Figure 6.

Digit 21 was the one with the highest peak (R\$ 894,773,692.79) and, according to the materiality represented, the budgetary expenses associated with it could be within the scope of the work of a possible audit. However, by the test of the first two digits, the budgetary expenses associated with this pair of digits do not present distortions related to the NBL. If the tests were used for auditing purposes in the institutions studied, the expenses that started with the number 22 should be analyzed in more depth, since they presented distortion in the z test (risk of fraud or error) and materiality (R\$ 513,352,221,72). The other digits that presented distortions have negative differences (scarcity of pairs of digits) or represent a smaller percentage in relation to the total.

In summary, considering the results presented, it is possible to observe the usefulness of the LNB to point out distortions in the digits associated with the budgetary expenses paid by the RFEPT, confirming the evidence proposed in hypothesis H1. The data in general showed compliance with the NBL by the MDA test; on the other hand, the chi-square test showed non-compliance in most of the tests carried out, being complemented by the z test, which pointed out the digits that presented distortions in relation to the NBL.

Thus, it is possible to verify the importance of the referred

Table 4- Compliance of the institutions to the first digit

Institutions that had the best performance				
UG	INSTITUITON	Z*	X <sup>2</sup>	MDA
158147	IF DE ALAGOAS	0	3.571	0.0066
158099	IF TRIA.MINEIRO	0	3.774	0.0067
158156	IF DO ACRE	0	4.705	0.0069
158155	IF DO RN	0	2.852	0.0077
158022	IF MINAS GERAIS	0	11.379	0.0081

Source: elaborated by the authors

\* Quantity of LNB divergent digits.

method to aid in the work of auditing the budgetary expenses paid by these institutions.

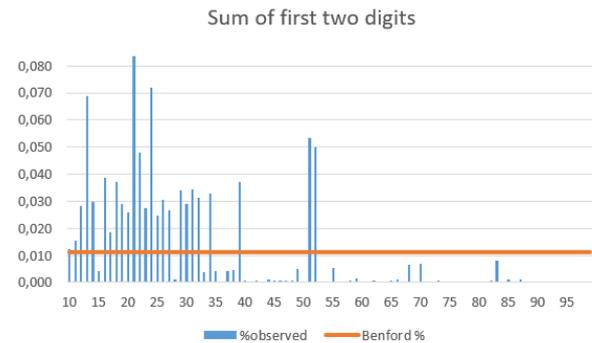


Figure 6. Graph of the test of the sum of the first two digits.

Source: elaborated by the authors.

#### 4.1.2 Compliance of the Management Units with the NBL

This section presents the performance of the Management Units (UG) that make up the Federal Network of Professional and Technological Education in relation to the application of the NBL. For this, data on budgetary expenses paid by these institutions in 2019 were considered, as it was the most recent year in which work routines had not yet been affected by COVID-19 (Castilho & Silva, 2020). A total of 23,755 amounts associated with paid commitments were analyzed, corresponding to a total amount of R\$ 10,711,338,369.33.

Table 4 presents the institutions that had the best performance with the tests for the first digit and the institutions that had the lowest performance. The results of the MDA test were used as the main parameter for classification, however, the values of the z test and the chi-square test were also considered.

Institutions that had the lowest performance				
UG	INSTITUITON	Z*	X <sup>2</sup>	MDA
158135	IF DO PARA	3	36.586	0.0255
158143	IF DE BRASILIA	2	17.479	0.0277
158144	IF MAT.GROSSO	3	77.676	0.0289
158150	IF DO AMAPA	4	64.956	0.0386
158132	IF MAT.G.DO SUL	5	213.537	0.0622

Table 5 presents the performance of ten institutions in relation to the tests applied to the second digit, separating them into two groups, according to the level of compliance. The results of the MDA test were used as the main parameter for classifying the units, however, the values of the z test and the chi-square test were also considered.

Table 5 - Compliance of the institutions to the second digit

Institutions that had the best performance					Institutions that had the lowest performance				
UG	INSTITUTION	Z*	X <sup>2</sup>	MDA	UG	INSTITUTION	Z*	X <sup>2</sup>	MDA
158147	IF DE ALAGOAS	0	2.805	0.005	158144	IF MATO GROSSO	6	100.161	0.0273
158141	IF DO RS	0	3.212	0.007	158136	IF PERNAMBUCO	3	21.078	0.0282
153015	CEFET DE MG	0	9.018	0.0075	158138	IF DA PARAIBA	4	37.326	0.0293
158121	IF NORTE DE MG	0	5.199	0.0076	158150	IF DO AMAPA	5	60.813	0.0440
158133	IF DO CEARA	0	4.141	0.0084	158132	IF MAT.G.DO SUL	4	230.00	0.0490

Source: elaborated by the authors

\* Quantity of LNB divergent digits.

In summary, the possibility of using the NBL at the UG level to find distortions in the values of paid budgetary expenses stands out, as many institutions showed good adherence to the NBL, but others showed relevant distortions. These results are in line with the findings of Nigrini (2012), who highlights that the data analyzed in a consolidated manner may be biased because the data from one institution influences the data from another, reflecting on the overall result. Thus, the expenses paid by the RFEPT deserve further analysis in view of the distortions presented by these Management Units in relation to the NBL, since, according to what Ribeiro and Monsueto (2015) and Ferrero et al. (2015) point out, these distortions do not necessarily mean that there was fraud, but only point to a need for further analysis.

#### 4.2 Analysis of Equity Expenses Incurred

For the purpose of comparison with the results of the paid budgetary expenditure, this section presents the performance of the Management Units that make up the Federal Network of Professional and Technological Education in relation to the application of the NBL, considering the equity expenses. For this, data on the equity expenses of these institutions in 2019 were considered. 93,053 amounts associated with these expenses were analyzed, corresponding to the total amount of R\$ 7,161,697,088.59.

Table 6 presents the results of the tests applied to the 2019 equity expenses of all consolidated management units.

Table 6 - Tests applied to the first digit of the RFEPT equity expenses

Digit	Observed Quantity	Expected Quantity	Observed Proportion	Expected Proportion	Z	χ <sup>2</sup>	MDA
1	27909	27992.48	0.300	0.301	<b>0.594*</b>	0.249	0.001
2	16028	16374.43	0.172	0.176	3.010	7.329	0.004
3	11472	11618.05	0.123	0.125	<b>1.453*</b>	1.836	0.002
4	8905	9011.56	0.096	0.097	<b>1.183*</b>	1.260	0.001
5	7182	7362.87	0.077	0.079	2.218	4.443	0.002
6	6415	6225.61	0.069	0.067	2.441	5.761	0.002
7	5697	5392.43	0.061	0.058	4.151	17.202	0.003
8	4946	4756.39	0.053	0.051	2.761	7.559	0.002
9	4435	4255.18	0.048	0.046	2.757	7.599	0.002
Total	92989					53.239	<b>0.0021**</b>

Source: elaborated by the authors.

\* Non-significant values (< 1.96), therefore compliant value; \*\*acceptable value.

Initially, it should be noted that the MDA test indicates that the data from the Management Units, when analyzed on a consolidated basis, are in the range of compliance with the NBL. According to the z test, it is observed that the digits that occur in a higher frequency than expected are the digits 2, 6, 7, 8 and 9, indicating that the processes of these institutions whose values of equity expenses start with such digits should be analyzed more deeply, considering the possibility of records with errors or some manipulation.

Unlike the result found with budgetary expenses, which showed only two digits in disagreement with the NBL, the tests applied to equity expenses point to five divergent digits, directing the need for analysis by the audit to a larger group of values.

Table 7 shows the performance of the institutions' equity expenses in view of the application of the NBL. The results of the MDA test were used as the main parameter for classification, however, the values of the z test and the chi-square test were also considered.

Table 7 - Compliance of the institutions' equity expenses to the first digit

Institutions with the highest compliance				
UG	INSTITUTION	Z*	X <sup>2</sup>	MDA
158516	IF STA. CATARINA	0	6.943	0.0038
158137	IF DO SUL DE MG	0	6.152	0.0039
158009	IF DO PARANA	0	9.6	0.0042
158124	IF GOIANO	0	5.595	0.0044
158147	IF DE ALAGOAS	0	8.268	0.0048

Institutions with lower compliance				
UG	INSTITUTION	Z*	X <sup>2</sup>	MDA
153019	UF DO PARANA	6	55.739	0.0174
158129	IF BAIANO	6	90.771	0.0193
153167	COL. PEDRO II	5	61.873	0.0201
158125	IF CATARINENSE	4	62.787	0.0214
158143	IF DE BRASILIA	8	154.74	0.0245

Source: elaborated by the authors.

By comparatively analyzing the results of budgetary and property expenditures, it appears that the institutions do not have the same classification in order of conformity, allowing one to verify the independence between such groups of expenditures in the NBL tests. This compromises the usefulness of using the LNB as audit evidence, according to hypothesis H2.

It is also observed that the tests directed to budgetary expenses point to a smaller group of distorted digits, representing greater discriminant power in the use of the

NBL to identify possible errors and fraud. In this way, the audit works, when using the NBL technique, should direct the analyzes by extracting budgetary information and use the equity information in a complementary way.

## 5. Conclusões

The present study analyzed the accounting compliance of budget and property expenses of the Federal Network of Professional and Technological Education, using the NBL methodology. For this, the behavior of values related to these expenses was observed, comparing them with the distribution defined in the Newcomb-Benford Law. In addition, a discussion was presented between the level of compliance with the LNB and the quality of the accounting information of these institutions.

The results allowed us to observe that there was a trend of increasing compliance of the consolidated budget data in relation to the NBL in the period from 2017 to 2019, pointing to a possible improvement in the quality of accounting information over these years. In 2020, however, despite the data showing compliance with the NBL, it did not follow the same trend as in previous years (greater compliance than the previous year), according to the MDA test. Therefore, the results presented may be a good parameter on the quality of information in the public sector, and may be useful for further research.

It should be noted that from 2018 onwards, the investigated institutions adopted the Integrated Report, in addition to other measures that may have influenced the improvement of the quality of accounting information, reinforcing the results found. The year 2020, in turn, presented several challenges arising from the effects of the COVID-19 pandemic on work routines in several organizations, which may have influenced the quality of accounting information.

It was possible to observe that data on budgetary expenses paid by the Federal Network of Professional and Technological Education can be evaluated through the application of the NBL, making it possible to use it to verify distortions that may be related to errors or fraud, contributing to the planning of audits and in the control of the executed resources.

It should be noted, however, that when the analysis is directed to equity expenses, a greater number of non-compliant digits are observed, expanding the amount of data to be analyzed if the result were used for a possible audit. Thus, the NBL has less discriminating power

to identify possible errors and fraud based on equity expenses.

The research limitation is the lack of crossing the results found with other information about the analyzed institutions, due to the unavailability of such data. For the same reason, the analysis window is short and this constitutes another limitation. Further studies will be able to verify the compliance trend of these institutions in subsequent years, including the unfolding of the Covid-19 pandemic.

As a suggestion for future research, representative elements of each institution can be raised to verify whether greater compliance with the NBL may be associated with a more consolidated governance structure, greater frequency of audit procedures, higher level of experience of accountants, among other elements. Audit reports can also be explored to verify whether the distortions pointed out by the NBL are associated with the detection of inconsistencies in the entities' accounts in order to ratify the effectiveness of the NBL.

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