

## The Applicability of the Newcomb-Benford Act in the Process of Controlling the Balance Sheet of Organizations

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### Abstract:

*This paper presents a case study on the applicability of the Newcomb-Benford Law in the process of controlling and detecting fraud in the economic and financial results of the financial statements of the organizations. Its applicability was demonstrated using the frequencies of the observed data, compared to the Newcomb-Benford Act standard based on the accounting model, in the documentary analysis of financial statements from the first quarter of 2007 to the second quarter of 2017 of one company of international renown, obtained from the Investor relations website. Analyzes of balance sheet balances ensure that the organization's economic and financial results are monitored more deeply, thus allowing managers to detect problems and possible distortions in results over time.*

**Keywords:** Newcomb-Benford Law; Accounting; Financial Statements; Contabilometry.

## 1. INTRODUCTION

In between the main administrative functions, those that most interest the accounting in the exercise of its social functions are the planning and the control. In the control methods, the company can count on mathematical-statistical instruments. Among the various possibilities of the use of mathematics and statistics in the control of companies, the application of a series of numbers and it's a tendency to contribute to work of later verification and decision making is focused.

There are efficient quantitative methods that use mathematics and specifically the theory of probabilities to aid in decision-making and control. Managers are always looking for methods and tools that are easy to implement and inexpensive. Also there is the occurrence of the need for handling an increasing number of information slimes time per shrinking, demanding manipulate and correlate information in order to structure and predict future changes in the market and thus, there is a need to use different science, technology, and innovation tools in order to assist managers in monitoring and monitoring their planning.

This paper aims to test the accuracy of the Newcomb-Benford Law for both the first and the second digits of financial results and to detect evidence of possible errors, manipulations or fraud in accounting balances of a machinery and equipment company. The relevance of the work is proven based on the results obtained in several applications of the law, in which are presented the procedures for the construction of an accounting model, able to offer a more detailed monitoring in the control of the economic and financial results of the organizations, assisting managers in detecting problems and distortions of results that are at odds with plans and goals, and contributing to the fight against corruption and manipulation of economic and financial data of organizations and financial statements over time.

## **2 THEORETICAL REFERENCE**

Over time, there is a need to follow up with greater depth in controlling the economic and financial results published in the financial statements of the organizations, so that it is possible to monitor and detect problems such as distortions of results that may be at odds with policy of plans and goals predefined by within the planning and strategies of its managers in addition, to create a management policy against manipulation and or fraud.

### **2.1 THE NEWCOMB-BENFORD LAW**

The Newcomb-Benford Law on accounting has been consolidating over time, where recent advances have been demonstrated in applications in auditing and fraud detection.

Simon Newcomb (1835 - 1909), writer, astronomer, and mathematician, was the first to observe the anomalous behavior of the digits. He noticed that the first pages of the logarithmic books or tables that began with the first numbers were dirtier when compared with the others, thus showing that its users tended to consult more frequently the numbers initiated by the smallest digits (RIBEIRO, MONSUETO, 2015).

Benford (1938), based on this observation by Newcomb, began research using 20,229 sets of numbers from a variety of sources, such as population, mortality rate, game statistics, river areas, and others. He constructed statistical tables with the data obtained and observed that the frequencies of occurrence for the digits 1 to 9 differ from the one presented by the traditional probability, that is, the digit 1 (one) tends to appear in 30% of the cases, a percentage that much higher than expected 11% (1/9) of the traditional probability.

Hill (1995), Pinkham (1961), and Raime (1969) show through research in the field of Probability Theory that the Newcomb-Benford Law applies to the set of data that are scalar invariant and comes from different data sources. This result is obtained through a rigorous analysis of the Central Limit Theory, interpreted in the form of theorems for the mantissa of random variables on the effect of multiplication. Therefore, when the number of variables grows, the density function tends to a logarithmic distribution.

Francischetti (2007, pg. 28) complements:

This phenomenon is not difficult to perceive, but there are examples in which it becomes evident, as in looking at the numbers of houses on a street. How many houses are there on average in the street? If we consider fifty (50) it is easy to count how many houses begin with the digit 1. There are eleven: house number 1, a 10, a 11, a 12, and so on until the 19th house. The probability of a randomly chosen house starting at digit 1 is  $11/50$  or 22%. In contrast, there will be only one house that starts with the digit 9, it is number 9. The probability of a house starting with this digit is  $1/50$ , that is, only 2 %.

Nigrini (2000) paved the way for the application of the Newcomb-Benford Act to identify tax evasion and fraud detection by creating an accounting model based on the relationship between law and hypothesis testing. The first investigator to use the Newcomb-Benford Act to uncover fraud.

Francischetti (2007) verified the application of the Newcomb-Benford Law in the control of the financial statements. Their study made it possible to conclude the validity of the Law's application in the financial statements of companies, thus allowing managers to detect problems and distortions of results, which disagree with the pre-established plans.

Ribeiro and Monsueto (2015), demonstrated the effectiveness of the Newcomb-Benford Law, concerning agility and consistency for decision making, through a probabilities-based approach to controlling financial launches in a company that provided services and commercialized products for the industrial sector.

Recently, Cella and Rech (2017) presented research that verified the applicability of the Newcomb-Benford Law in the detection of fraud occurred in Petrobras. They analyzed the frequencies of occurrence of the first digits of the values of the *red flag* elements during the period from 2004 to 2012. The results analyzed showed discrepancies for the Newcomb-Benford Law, however, 40 companies listed on the BM&F Bovespa presented higher discrepancies in your data when compared with the Petrobras will. Thus, the authors concluded that when applied only to the first

digit, the Law was not efficient to detect fraud in Petrobras, the results were not satisfactory, evidencing the need for further studies to detect possible fraud.

However, Oliveira et al. (2018) verified through the analysis of Petrobras' balance sheets for the period of the first quarter of 2008 and the second quarter of 2015, between the beginning of the investigation of the Federal Police of Brazil in the operation of the jet, until the suspension of the publication of its economic results and financial statements for a complete review, correction and modification based on the *impairment* of its assets. We found a deviation from the model of the Newcomb-Benford Law, only in the balances of the two-digit balances for the analysis of the first digit, validating the results, since this indication could be due to a particularity of the market or management, However, as the second, third and fourth digits were analyzed, there were expressive anomalies generalized by the accumulation of values distributed over time, burdening the balances of their financial statements and consequently distorting their logic of distribution.

## 2. 2 ACCOUNTING

For accounting purposes, one has the measurement of economic and financial relations and tests its validity. It is an economic analysis in which the theoretical approach is usually formulated in explicit mathematical terms, being constantly combined through complex statistical procedures with empirical evaluations of behavioral phenomena of an economic-financial nature.

Corrar and Théophilo (2004) present the main advantages of accounting, the possibility of solving a wide variety of problems and allowing accountants to offer more useful and adequate information, taking accounting closer to objectivity.

The use of accounting models based on quantitative methods has become increasingly frequent as a result of the rapid development of information technology and the use of microcomputers. It is the task of accountants to transform data into information that is capable of influencing decisions, and accounting helps to identify and understand various possible relationships between the real elements of firms. (FIGUEIREDO, 2001).

### 3 METHODOLOGY

The development work is guided by a case study with the construction of an accounting model to help on control and toned the decisions of an internationally renowned company located in Campinas Region / SP in Brazil, working in the field of machinery and equipment, by comparing the analysis of the balances of the balance sheet accounts, obtained on the IR website (Investor Relations) , from the first quarter of 2007 to the second quarter of 2017 with the premises and relations existing with the Newcomb-Benford Law .

The research is characterized as descriptive and qualitative. According to Andrade (2002), because is careful to observe, record, analyze, classify and interpret certain facts that the researcher can not interfere with. Its quantitative characteristic is given by, according to Beuren (2006) the use of statistical tools in the elaboration.

For Yin (2004, p. 21 ) the case study is "*... an empirical inquiry that investigates a contemporary phenomenon within a real-life context when the boundary between phenomenon and context is not evident and where multiple sources of evidence are used.* "

### 4 DATA ANALYSIS

The use of the model introduced in the US by Nigrini (2000), adapted and simplified in Brazil. Santos, Tenorio and Silva (2003), based on the relationship of the Newcomb-Benford Law with hipot test eses, Z-test, and Thurs- Square.

The Z-Test is indicated to judge the legitimacy of a claim about a population proportion. For more than 20 observations for both averages and proportions, the tests measure the deviation of a sample statistic from a theoretical (alleged) value, that is, ( p o - p e). Both tests rely on standardized normal distribution for critical values (STEVENSON, 2001).

The Qui- square test is applied to test if two events are independent, that is if the knowledge of the occurrence of one of them tells us something or nothing about the occurrence of the other (Downing et al., 2005).

The adherence test is characterized as a statistical process, used to test the hypothesis that a given probability distribution (  $p_e$  ) fits a set of observed data (  $p_o$  ). These tests are used to evaluate statements about the distribution of values in a population. (Stevenson, 2001).

You can view the frequency distributions for the four digits in Table 1.

**Table 1: Frequency of the first four digits, calculated according to the Newcomb-Benford Act**

Digits	First	Second	Third	Fourth
0	0.00%	11.97%	10.18%	10.02%
1	30.10%	11.39%	10.14%	10.01%
2	17.61%	10.88%	10.10%	10.01%
3	12.49%	10.43%	10.06%	10.01%
4	9.69%	10.03%	10.02%	10.00%
5	7.92%	9.67%	9.98%	10.00%
6	6.69%	9.34%	9.94%	9.99%
7	5.80%	9.04%	9.90%	9.99%
8	5.12%	8.76%	9.86%	9.99%
9	4.58%	8.50%	9.83%	9.99%

Source: Retrieved from " Find financial fraud whit Benford's Law Invest Excel "by S. Kahn, 2016.

The accounting model checks the variations between the frequencies by proving the Z-Test and Qui- Square of the occurrence of distortions and manipulations about the Newcomb-Benford Law.

#### 4.2 ACCOUNTING ANALYSIS

To provide a correlation and acceptance of the presented analysis, the accounting model of Nigrini (2000), based on the relation between the Newcomb-Benford Law and Hypothesis Tests (Z-Test and Qui-Square), was executed in the balance sheets. This model had the addition and configuration according to the conditions of the Brazilian Accounting by Santos, Tenório, and Silva (2003).

In the tables below, we find the Z and Qui-Square (  $X^2$  ) values in the analysis of the total balances of the balance sheets of the first quarter of 2007 to the second quarter of 2017, according to the first, second, third and fourths digit.

**Table 2 : First digit of balance sheet balances 1st Quarter 2007 to 2nd Quarter 2017**

Digits	Quant. (n)	Balance (po)	Law NB (b)	Deviation (po-pe)	Module  po - pe	Term Correction	Po (po x n)	Pe (pe x n)	Difference (Po-Pe)	Z Test	X <sup>2</sup>
1	558	0,3029	0,3010	0,0019	0,0019	0,00027	550,1238	547	3	0,151	0,022
2	384	0,2085	0,1761	0,0324	0,0324	0,00027	378,5798	320	59	3,592	10,811
3	183	0,0993	0,1249	-0,0256	0,0256	0,00027	180,4169	227	-46	3,263	9,518
4	214	0,1162	0,0969	0,0193	0,0193	0,00027	210,9794	176	35	2,736	6,957
5	143	0,0776	0,0792	-0,0015	0,0015	0,00027	140,9815	144	-3	0,202	0,055
6	124	0,0673	0,0669	0,0004	0,0004	0,00027	122,2497	122	1	0,017	0,004
7	94	0,0510	0,0580	-0,0070	0,0070	0,00027	92,67318	105	-13	1,220	1,517
8	77	0,0418	0,0512	-0,0094	0,0094	0,00027	75,91314	93	-17	1,756	3,104
9	65	0,0353	0,0458	-0,0105	0,0105	0,00027	64,08252	83	-19	2,080	4,350
TOTAL	1842	1,000	1,000	0,000			1816	1816	0		36,338

Source: Prepared by the authors, based on data collected from the research.

For the Qui- square test, concerning the X<sup>2</sup> table, the expected critical value is 15.507, at 5% significance, as shown in our X<sup>2</sup> table, our total was 33,057. When there is the value of the chi-squaree (X<sup>2</sup>) calculated to be above the critical value of the chi-squaree (Tabulated) indicates the null hypothesis (Ho: po = p<sub>e</sub>) and can be rejected, that is, "the variations between observed and expected population proportions are not in the region of acceptance" (FRANCISCHETTI, 2007 p.70).

When analyzed individually, the first digit obtained, with degree of freedom equivalent to 8, is observed in the Z-Test values above the critical Z value that is 1,960 for digits 2, 3, 4 and 9. This result in the indicates non-standard distortions described by the Newcomb-Benford Act . In this way, a more critical and detailed examination of the balances found in the company balance sheet accounts that starts with numbers 2, 3, 4 and 9 is justified as its first digit.

If irregularities are found in the disposition of the balances, the inspections and corrections should be carried out by the managers of the organization, so that it does not happen again. To verify the veracity of the analyzed data with the distortion detected in digits 2, 3, 4 and 9, in table 7, you can check the frequencies for the second digits of balance sheets.

**Table 3 : Second digit of balance sheet balances 1st Quarter 2007 to 2nd Quarter 2017**

Digits	Quant. (n)	Balances (po)	Law NB (b)	Deviation (po-pe)	Module  po - pe	Term Correction	Po (po x n)	Pe (pe x n)	Difference (Po-Pe)	Z Test	X <sup>2</sup>
0	216	0.1189	0.1197	-0.0007	0.0007	0.00028	216.00	217.34	-1.34	0.061	0.008
1	167	0.0920	0.11139	-0.0219	0.0219	0.00028	167.00	206.82	-39.82	2.905	7.668
2	166	0.0914	0.1088	-0.0174	0.0174	0.00028	166.00	197.62	-31.62	2.345	5.059
3	180	0.0991	0.1043	-0.0052	0.0052	0.00028	180.00	189.46	-9.46	0.688	0.473
4	195	0.1074	0.1003	0.0071	0.0071	0.00028	195.00	182.16	12.84	0.964	0.905
5	184	0.1013	0.0967	0.0046	0.0046	0.00028	184.00	175.57	8.43	0.630	0.405
6	167	0.0920	0.0934	0.0014	0.0014	0.00028	167.00	169.57	-2.57	0.167	0.039
7	188	0.1035	0.0904	0.0132	0.0132	0.00028	188.00	164.08	23.92	1.917	3.487
8	189	0.1041	0.0876	0.0165	0.0165	0.00028	189.00	159.03	29.97	2.447	5.649
9	164	0.0903	0.0850	0.0053	0.0053	0.00028	164.00	154.35	9.65	0.770	0.603
<b>TOTAL</b>	<b>1816</b>	<b>1.0000</b>	<b>1.0000</b>	<b>0.0000</b>			<b>1816.0</b>	<b>1816</b>	<b>0.00</b>		<b>24.297</b>

Source: Elaborated by the authors, based on data collected from the research.

Analyzing the total balances of the balance sheets, it was found above the critical values of Z for 1,960 digits 1, 2 and 8.

For the test and Qui- Square ( X<sup>2</sup> ), the total was 24,297, an above-expected value that is 16,919, for 9 degrees of freedom with a significance level of 5%. These differences between the tabulated X<sup>2</sup> and that obtained in the analysis of the second digit are justified about the differences observed in the critical test Z in digits 1, 2 and 8. In this case, a verification must be carried out by the managers of the organization, of the documents and entries that make up these balances in the accounting accounts for then, to be able to prove the veracity of the tests performed.

**Table 4 : Third digit of balance sheet balances 1st Quarter 2007 to 2nd Quarter 2017**

Digits	Quant. (n)	Balances (po)	Law NB (b)	Deviation (po-pe)	Module  po - pe	Term Correction	Po (po x n)	Pe (pe x n)	Difference (Po-Pe)	Z Test	X <sup>2</sup>
0	198	0.1167	0.1018	0.0149	0.0149	0.00029	211.88	184.84	27.04	2.057	3.957
1	170	0.1002	0.1014	0.0012	0.0012	0.00029	181.92	184.10	-2.18	0.128	0.026
2	165	0.0972	0.1010	0.0037	0.0037	0.00029	176.57	183.37	-6.79	0.488	0.252
3	158	0.0931	0.1006	0.0075	0.0075	0.00029	169.08	182.64	-13.56	1.016	1.007
4	155	0.0913	0.1002	0.0088	0.0088	0.00029	165.87	181.92	-16.05	1.213	1.417
5	189	0.11114	0.0998	0.0116	0.0116	0.00029	202.25	181.22	21.04	1.605	2.442
6	153	0.0902	0.0994	0.0092	0.0092	0.00029	163.73	180.51	-16.78	1.274	1.560
7	168	0.0990	0.0990	0.0000	0.0000	0.00029	179.78	179.82	-0.04	0.003	0.000
8	150	0.0884	0.0986	0.0102	0.0102	0.00029	160.52	179.13	-18.61	1.423	1.934
9	191	0.1126	0.0983	0.0143	0.0143	0.00029	204.39	178.45	25.94	2.003	3.771
<b>TOTAL</b>	<b>1697</b>	<b>1.0000</b>	<b>1.0000</b>	<b>0.0000</b>			<b>1816.0</b>	<b>1816</b>	<b>0.00</b>		<b>24.297</b>

Source: Elaborated by the authors, based on data collected from the research.

For the third digit of the analyzes the expected value for the X<sup>2</sup> test of 16.919, for 9 degrees of freedom, there is a X<sup>2</sup> of 16,366. When we obtain a Chi-square value smaller than the critical value (tabulated), it indicates that the null hypothesis (Ho ) must be accepted.

Analyzing the table with the results of the Z-Test, for the third digit, the digits 0 and 9 were found with values above the limit

that is 1.96. As found in test  $X^2$ , these differences were not enough for the measured result to be higher than the table, thus leaving the acceptance concept for the third digit analysis within the analyzed period.

Critical values presented for the fourth digit are 16.919 for Test  $X^2$  and 1.96 for the Z-test, found in Table 9, a result of 46.947 to  $X^2$  analysis indicates that the null hypothesis ( $H_0$ ) may be rejected. Analyzing the Z-Test table, we found that the digits 0, 5, 8, and 9 were higher than expected.

**Table 5 : Fourth digit of the balances of the balance sheets 1st Quarter 2007 to 2nd Quarter 2017**

Digits	Quant. (n)	Balances (po)	Law NB (b)	Deviation (po-pe)	Module  po - pe	Term Correction	Po (po x n)	Pe (pe xn)	Difference (Po-Pe)	Z Test	$X^2$
0	226	0.1288	0.1002	0.0286	0.0286	0,00028	233.86	181.92	51.94	4,019	14,827
1	153	0.0872	0.1001	-0.0130	0.0130	0,00028	158.32	181.85	-23.53	1,799	3,045
2	171	0.0974	0.1001	-0.0027	0.0027	0,00028	176.94	181.78	-4.83	0,338	0.129
3	153	0.0872	0.1001	-0.0129	0.0129	0,00028	158.32	181.71	-23.39	1,789	3,011
4	160	0.0912	0.1000	-0.0089	0.0089	0,00028	165.56	181.63	-16.07	1,217	1,422
5	149	0.0849	0.1000	-0.0151	0.0151	0,00028	154.18	181.56	-27.38	2,102	4,130
6	193	0.1100	0.0999	0.0100	0.0100	0,00028	199.71	181.49	18.22	1,385	1,828
7	197	0.1123	0.0999	0.0123	0.0123	0,00028	203.85	181.42	22.43	1,714	2,772
8	140	0.0798	0.0999	-0.0201	0.0201	0,00028	144.87	181.35	-36.49	2,815	7,340
9	213	0.11214	0.0998	0.0215	0.0215	0,00028	220.40	181.28	39.12	3,022	8,443
<b>TOTAL</b>	<b>1755</b>	<b>1,0000</b>	<b>1,0000</b>	<b>0.0000</b>			<b>1816,0</b>	<b>1816</b>	<b>0.00</b>		<b>46,947</b>

Source: Elaborated by the authors, based on data collected from the research.

The deviations presented in our analysis indicate that the data should be determined more closely by verifying the company's accounting records and books to arrive at a real explanation of such distortions.

Onstage are differences between higher expected values for the first, second and fourth digits no  $X^2$  (Qui- square test). This demonstrates that there is a problem for the whole balance willing over time the accounts of the balance sheets of the company. In this case, one should seek to analyze each set of digits separately, that is, to distribute them annually so that it is possible to find in which particular year these distortions have begun. In this way, we can find the causes and origins that justify these results for the  $X^2$  ( Qui-square test) through the indications based on the results of the Z-Test, thus indicating, through the digits of the balances, which accounts should be analyzed.

It is necessary to validate the tests by verifying the vouchers and documents according to the differences obtained in each digit. Although, this is not possible n this work, as it was used data

published on social networking site with investors (RI) of the analyzed company should -If suggest any procedures that may be linked to the results obtained in our study, or be:

A) Fragmentation tendency or a subdivision of values. For example, a sale in the amount of R \$ 50,000.00, divided into 5 times of R \$ 10,000.00, will accumulate values with significant digits 1 instead of the digit 5;

B) Reclassification of entries, according to information in the explanatory notes, since this procedure will reduce a certain balance of a particular account and increase the balance of another account so that the results come out of the default or the previous one and

C) Occurrence of investments in each period, resulting in a discontinuity in the generation of normal digits of the company's daily transactions and burdening the balances of accounts, such as the income tax due.

## **5 FINAL CONSIDERATIONS**

The application of the Newcomb-Benford Law, proposed by the accounting model in the financial statements and financial data of the organizations, provides a greater depth of detail for the monitoring and control of its results, directly in the execution of the pre-planned processes and projects. This allows the detection of problems and distortions of results daily, not allowing any deviation to create negative and unsustainable consequences in the future of the organization.

By analyzing the results, we could see that the Newcomb-Benford Act is an aid method to assist managers and auditors in detecting accounting errors, typos, and even fraud in the context of a traditional accounting audit.

Based on the investments made, it was verified that the analysis of balance sheet balances, during the first quarter of 2007 up to the second quarter of 2017, is following the Newcomb-BenfordLaw. The analysis performed by the accounting model by means of the verification of the tests Z and chi-squaree ( $X^2$ ) the occurrence of Alanco b distortions patrimonial analyzed showed that should be analyzed and assessed closely and in this way it can be considered

that the Newcomb-Benford's Law is a tool to determine the default behavior of the balances of balance sheets, as is evident in a profile in which the distribution of frequencies of occurrence of the first, second, third and fourth digit s should behave.

In this way, it can be concluded that the application of the Newcomb-Benford Law, in control of the financial statements of the organization can provide managers with information on whether their economic and financial results comply with current legal standards.

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