

## SPECIAL ISSUE ARTICLE

## Can Benford's Law explain CEO pay?

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## Abstract

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**Research Question/Issue** This study applies the statistical properties of Benford's Law to CEO pay. Benford's "Law" states that in an unbiased dataset, the first digit values are usually unequally allocated when considering the logical expectations of equal distribution. In this study we question whether the striking empirical properties of Benford's Law could be used to analyze the negotiating power and preferences of CEOs. We argue that performance-based or market-determined compensations should follow Benford's Law, demonstrating no direct negotiation by the CEOs. Conversely, deviation from Benford's Law could reveal CEO negotiating power or even preference.

**Research Findings/Insights** Our analysis shows that market-determined "Option Fair Value" (the dollar value of stock options when exercised) conforms closely to Benford's Law, as opposed to "Salary", which is fully negotiated. "Bonus", "Option Award", and "Total Compensation" are generally also largely consistent with Benford's Law, but with some exceptions. We interpret these exceptions as negotiation by the CEOs. Surprisingly, we found that CEOs prefer to be paid in round figure values, especially "5". We use Benford's Law to study the negotiating powers of CEOs vs. that of other executives. Finally, we compare the negotiating tactics of CEOs before and after SOX and analyze the impact of firm size on their compensation.

**Theoretical/Academic Implications** This study introduces Benford's Law and its applications within the corporate governance literature.

**Practitioner/Policy Implications** This method could be used by academics, industry and regulators to uncover compensation patterns within large business departments and/or organizations or even entire industry segments.

## KEYWORDS

Corporate Governance, Benford's Law, Executive Compensation, Negotiating Power, Preference

## 1 | INTRODUCTION

CEO pay has emerged as a prolific field of theoretical and empirical research (Bebchuk, Cremers, & Peyer, 2011; Bebchuk, Fried, & Walker, 2002; Jensen & Meckling, 1976; Jensen & Murphy, 1990b; Murphy, 1999), and because of the diverse research methods offered to study the many aspects of CEO negotiations, the compensation literature has benefited from being on the frontiers of this domain (Boyd, Haynes, & Zona, 2011; McNulty, Zattoni, & Douglas, 2013; Shleifer & Vishny, 1997; Vives, 2006). Despite the intense interest in the theme, however, several lacunae still remain in our understanding of CEO pay. Chief among them are the indicators that could detect the preferences of

CEOs and the intensity with which they negotiate their compensation with boards. In this paper, we apply a novel method that allows us to distinguish market-determined pay from negotiated CEO compensation. This distinction is important because the more CEOs negotiate their pay, the more is revealed about the power balance between this group of professionals and the compensation committees of company boards (Adams, Almeida, & Ferreira, 2005; Bebchuk et al., 2002; Finkelstein, 1992).

Executive compensation—which in all US-listed firms is partly performance-based—depends on predetermined payment arrangements as well as a number of accounting and market-based performance indicators. A CEO can negotiate the fixed part of his/her pay, but the realization of performance-linked compensation is ideally dependent on

the market. This paper is based on the premise that the negotiated part of pay is determined by the negotiations between CEOs and boards. The rest, however, is determined by the market. The key questions here are how CEOs bargain for the negotiated part of the fixed compensations and if their approach has any influence on the power balance between them and the boards, and if the CEOs have preferences.

In our analysis, we use a unique method known as Benford's Law (Benford, 1938). This "law" can be explained with the aid of a simple mental problem: how many times could the first digits of an unbiased dataset of a thousand randomly selected stock prices take the value of "1"? A logical answer to that question would be: just as often as the value of "9", or any other mid-value for that matter. Counterintuitively, however, Benford (1938)—and before him Newcomb (1881)—found that first digit values are not as equally distributed as one might expect. In a randomly distributed unbiased dataset of stock prices, for example, "1" is the first digit almost 30.1 percent of the time, whereas "9" occurs only 5 percent of the time (Corazza, Ellero, & Zorzi, 2010; Ley, 1996). This statistical phenomenon has been found in all unbiased datasets; studies have confirmed its existence on the basis of data from disparate fields (Abrantes-Metz, Kraten, Metz, & Seow, 2012; Benford, 1938; Leemann & Bochsler, 2014; Mir, 2012; Nigrini, 1996; Nigrini & Mittermaier, 1997). Although there is no universal mathematical explanation for this phenomenon, which is no different from the "bell curve" of normal distribution, its empirical validity is too striking to ignore (Patel & Read, 1982; Raimi, 1976). In social sciences, particularly in financial accounting literature, scholars and practitioners have used Benford's Law as a random number test for detecting offences such as earnings management (Carslaw, 1988; Thomas, 1989) and other types of accounting frauds (Nigrini, 1999).

Extending this logic to the corporate governance literature, especially to executive compensation datasets, we propose that performance-based or market-linked compensation on which executives have no direct or indirect influence, should behave as randomly distributed unbiased datasets. Upon meeting this criterion, the first/second digits of the numbers from these datasets should then conform to the stylized pattern or the expectations of Benford's Law. Using this novel approach, any level of undervalued or potentially unknown negotiating "power" or "preference" of (top) executives, such as CEOs, could be uncovered. In effect, Benford's Law could be a test for the unbiasedness of performance-based or market-linked compensation components. With respect to the compensation data, the only viable explanation for any bias detected would be negotiations between CEOs and their firms, identifying the former's negotiating preferences for certain initial digits.

The focus on starting digits as a "cognitive reference point" is not entirely new. It has had quite a long history in psychology and marketing studies (Fraser-Mackenzie, Sung, & Johnson, 2015: 67). Indeed, laboratory experiments have demonstrated that individuals interpret numbers sequentially, starting from the first digit on the left, which in the psychology literature is known as the "left-digit-effect" (Hinrichs, Yurko, & Hu, 1981; Poltrock & Schwartz, 1984). In corporate governance, the question about what motivates executives is a relevant one, especially when analyzing the issue of executive compensation (Jensen & Meckling, 1976). Gaining knowledge of how executives negotiate the various aspects of their compensation and being able

to identify (subtle) biases could help enormously in better understanding future compensation structures and planning them more effectively. The starting digits of a compensation component, specifically the first and the second digit, determine the size of the final compensation. If we assume on the basis of the Jensen and Meckling (1976) agency construct, that managers prefer more compensation to less, the compensation components with larger values will reflect a stronger "commitment" in the manager–firm relationship. If we also assume that all compensation is performance-based or market-determined, we could interpret deviations from Benford's principle as the manifestation of negotiating power and preferences. However, we have some particular ideas about the anomalies between compensation that is performance-based or market-linked and that which is negotiated by CEOs and their respective boards (Murphy, 1999). If we could establish this incongruity per individual compensation component using Benford's Law, we would not only demonstrate the validity of our approach, but we could also add this instrument as yet another useful asset to the corporate governance methodological toolbox. Via this method we hope not only to obtain new insights into the negotiating power/preference of CEOs, of which some have indeed remained unknown until now, we could also actually identify them.

The executive compensation data used for this study were obtained from the ExecuComp database maintained by S&P Capital IQ for firms listed on the US stock markets. Our study is divided into two parts. In the first part, we establish whether Benford's Law is a useful methodological tool. This is done by testing a dual hypothesis: (1) Benford's Law enables a correct differentiation between performance-based/market-linked compensation and negotiated ones, and (2) Benford's Law reveals the preferences of CEOs by indicating specific compensation choices. In the second part, Benford's Law is used to answer some long-standing research questions in the field of executive compensation, demonstrating its additional utility and usage.

We found that Benford's Law is able to successfully differentiate between concepts such as "Option Fair Value" and "Salary". Let us consider the first; this is a market-determined compensation, as top executives have no control over the dollar outcome of the Option Fair Value. The other is pre-negotiated. This distinction is an important one because it provides legitimacy to Benford's Law as a credible tool for studying aspects of the negotiating power and preferences of top executives. Specifically, we establish that CEOs cannot influence the first/second digits of the Option Fair Value. Most of the Salary components, however, show intense negotiations, both to the benefit and the disadvantage of CEOs. Furthermore, we also observed that "Bonus" and "Option Award", which are presumably performance-determined, can indeed suffer from some amount of negotiation, if not manipulation. One of the most startling findings of this study relates to the second digit, which shows that CEOs and other top executives prefer to receive their compensations in round figures, especially containing the digit value "5". In addition, "0" as second digit is found to be overrepresented as well, because most executives are generally also inclined to obtain a marginal increase in the third digit values.

Furthermore, we will provide three tests using Benford's Law as a demonstration of its usage in new and creative ways of addressing

commonly known problems in corporate governance literature. First, we will investigate whether CEOs—as the “winners” of the organizational tournament (Bratton, 2005; O'Reilly, Main, & Crystal, 1988)—are able to negotiate better compensation because of their superior managerial bargaining power (Bebchuk et al., 2002; Finkelstein, 1992). We indeed found that CEOs exercise their negotiating power to enhance their compensation, whereby they act as compensation maximizing agents (Jensen & Meckling, 1976). Next, we will try to determine whether the Sarbanes-Oxley Act has brought about any changes in the way in which CEOs negotiate their compensation. Especially given the growing evidence in support of the view that these regulations have indeed reduced some of the executive power at the top (Aono & Guan, 2008). We found evidence supporting the hypothesis that post-SOX, CEOs have changed their negotiating tactics. Since the introduction of SOX, CEOs have been observed to prefer larger starting digit values with respect to their fixed compensation, such as Salary. This preference can be considered as a means to mitigate their lower manipulation power as regards the variable compensation components. Finally, we study the relationship between firm size and compensation negotiations (Kostiuk, 1990). Using Benford's Law, we found that smaller firm CEOs do have a disadvantage when it comes to compensation negotiations.

We recommend the use of Benford's Law to both academics and industry participants as a valuable tool for studying emerging trends in the domain of executive and employee compensation. Regulators, for example, could use this instrument to study industry patterns in labor income and compensation. We are, however, aware of the fact that Benford's Law is only but a rudimentary empirical method, as it can only highlight a latent trend or point to an emerging one. To fully investigate the issue of CEO compensation, multivariate and multilevel analyses are still required. Nevertheless, the value of this unconventional method lies in its simplicity, uniqueness, and ingenuity.

This paper is structured as follows: In Section 2, we introduce the properties of Benford's Law along with its applications in the social sciences. In Section 3, we explain the analytical framework and present our hypothesis. We describe our data sources in Section 4 and explain our methodological approach and statistical tests in Section 5. The empirical results are discussed in Section 6. Finally, we close this paper with some concluding remarks and a brief description of the limitations of the research in Section 7.

## 2 | STUDYING CEO PAY USING BENFORD'S LAW

CEO pay is an extensive field of study, in which a wide range of qualitative and quantitative research methods and approaches can be used, especially in the analysis of executive compensation (McNulty et al., 2013; Shleifer & Vishny, 1997; Vives, 2006) in relation to CEOs (Boyd et al., 2011). In this section, we introduce the statistical properties of Benford's Law and explain how they could be used in testing the (un)biasedness of datasets. We then go on to explore whether Benford's Law could be used as a method to uncover facets of CEO negotiation and preference.

### 2.1 | Benford's Law

In his paper in the *Proceedings of the American Philosophical Society* (Benford, 1938), it was Frank Benford who observed that the “first pages of a table of common logarithm show more wear than do the last pages” (Benford, 1938: 551). In a remarkable coincidence, back in 1881, Simon Newcomb made a similar observation when using his logarithmic tables. Based on this observation both scholars concluded that, since the first few pages of their books had obviously been used more often than the last pages, the frequency of the values at the first digit position of numbers in a randomly distributed unbiased dataset may be unevenly distributed (Benford, 1938; Newcomb, 1881). They specifically found that the frequency of the value “1” as the first digit of data-points in an unbiased (randomly distributed) dataset get skewed at 30.1 percent. This frequency continued to decrease with an increase in value, starting with “2” at the first digit position until “9”, which occurred 4.5 percent of the time. Similarly, the values of the second digit position were also not equally distributed across “0” to “9”. Here “0” occurred the most often, at 11.97 percent, while “9” occurred only 8.5 percent of the time. This stylized pattern in randomly distributed unbiased datasets became known as *Benford's Law*, despite the fact that Newcomb (1881) had been the first to discover it.<sup>1</sup>

Although this anomaly in randomly distributed unbiased datasets cannot be fully explained by mathematicians (see, e.g., Raimi, 1976: 536), they—including Benford—agree that its empirical application could be used in testing the “honesty or validity of purportedly random scientific data”.<sup>2</sup> Benford (1938) describes the statistical properties of his “Law” using a dataset of  $N$  numbers, each with  $n$  digits using a logarithmic function as reproduced in full below. For the sake of brevity, we describe the model using a two-digit dataset ( $n = 2$ ). In the two-digit dataset of  $N$  numbers, let us assume  $a$  as the first digit, which ranges between nine values: “1” to “9”. The function  $F_a$  describes the frequency of each of the nine possible values in the first digit position:

$$F_a = \log\left(\frac{a+1}{a}\right) \quad (1)$$

If in this two-digit dataset, where each number is denoted as  $ab$ ,  $a$  is the first digit, then  $b$  is the second digit. Calculating the frequency of the second digit  $b$  is more complex than that of the first digit  $a$ . For the  $b$ th place, there are ten possibilities instead of nine, ranging from “0” to “9”. So the key addition is the placeholder value “0”. If  $ab$  is a number in the  $N$  data-point dataset, the next number will inevitably be  $(ab + 1)$ . In this model, the frequency with which any of the ten values occurs in the second digit  $b$  position in the dataset is indicated by the function  $F_b$ , as shown below (for more detail, see Benford, 1938):

$$F_b = \left[ \log\left(\frac{ab+1}{ab}\right) \right] / \left[ \log\left(\frac{a+1}{a}\right) \right] \quad (2)$$

Applying the same logic, the  $n$ th digit statistical expansion of the  $n$  digit number in a dataset of  $N$  data-points is as follows:

$$F_n = \left[ \log \left( \frac{abc\dots m(n+1)}{abc\dots mn} \right) \right] / \left[ \log \left( \frac{abc\dots l(m+1)}{abc\dots m} \right) \right] \quad (3)$$

In Table 1, we provide the expected frequencies of the first and second digit values according to the stylized predictions of Benford's Law (Nigrini & Mittermaier, 1997).

## 2.2 | Benford's Law in practice

Frank Benford tested his theory (or Law) using the first digits of data-points from various datasets, such as population numbers, addresses, and death rates, etc. Based on this highly disparate data source, Benford (1938) tested the following hypothesis using his "Law" as a method: If the first and second digit numbers from a dataset conform to Benford's Law, this dataset is unbiased and ultimately randomly distributed. When this principle was exported to other research fields, a multidisciplinary body of literature developed.<sup>3</sup> It indeed appeared that unbiased and randomly distributed datasets from different fields conformed to the expectations of Benford's Law. In many studies, especially in the fields of accounting, finance, and management, it is now used as a test for (un)biasedness. In this paper, we do not aim to review the broad spectrum of disciplines in which studies have been inspired by Benford's Law. Instead, we specifically focus on this method's applications in the fields of accounting, finance, and management.

In a pioneering paper, Carslaw (1988) applied Benford's Law to study earnings management in 220 New Zealand (NZ) listed firms. Carslaw (1988) argued that meeting the financial expectations of investors is important for managers, and in doing so, the latter may be inclined to manipulate the income figures. In the case of manipulation, bias will reveal itself in the second digit distribution. Following an alternate hypothesis, if there is no manipulation of the income figures, the presumed unbiased and randomly distributed dataset should conform to the expectations of Benford's Law. Needless to say, the study did find evidence that income figures were manipulated by managers in such a way that an optimistic picture of firm performance was presented. Thomas (1989) followed up the NZ study by applying Benford's Law to US listed firms, data for which were provided by

**TABLE 1** Benford's Law: Expected frequencies

Digit	1st digit (%)	2nd digit (%)
0	–	11.968
1	30.103	11.389
2	17.609	10.882
3	12.494	10.433
4	9.691	10.031
5	7.918	9.668
6	6.695	9.337
7	5.799	9.035
8	5.115	8.757
9	4.576	8.500

Source: Nigrini and Mittermaier (1997)

the Compustat database. Similarly, Nigrini (2005) used Benford's Law in a case study of the earnings per share (EPS) data of Enron Inc. during the period 2001–2002, when the company submitted its amended financial statements. Here, the main hypothesis was that, if Enron had not manipulated its books, the dataset would conform to the digit distribution of Benford's Law. As somewhat expected, however, it was found that Enron had manipulated its EPS by biasing the figures upwards. Similar evidence of earnings management by "rounding of figures" is found in many other studies conducted in different countries (Das & Zhang, 2003; Guan, He, & Yang, 2006; Kinnunen & Koskela, 2003; Lin & Wu, 2014; Saville, 2006; Skousen, Guan, & Wetzel, 2004; van Caneghem, 2002). A policy research study using Benford's Law, however, showed that cosmetic earnings management "noticeably decreased" after the Sarbanes-Oxley Act of 2002 (Aono & Guan, 2008).

In the audit literature, Benford's Law has proved especially useful in uncovering fraud and misreportings. Nigrini (1994, 1999) and Nigrini and Mittermaier (1997) pointed out that Benford's Law could become a valuable "digital and number test" to support audit procedures. In their view, the approach could be useful to auditors in checking the "authenticity of lists of numbers by comparing the actual and expected digital frequencies" (Nigrini & Mittermaier, 1997: 52). A study by Guan et al. (2006), which highlights the effectiveness of auditing in improving the quality of information, found on the basis of Benford's Law that the degree of cosmetic earnings management is "less severe" in the fourth quarter than in the other three quarters.

Benford's Law was also applied in finance literature by De Ceuster, Dhaene, and Schatteman (1998), Dorfleitner and Klein (2009) and Shawn and Kalaichelvan (2012), which explored stock index data. Corazza et al. (2010) studied the stock prices of and returns on assets in the S&P 500 Index. Perhaps not surprisingly, they found that the first digits of the prices and returns followed the expectations of Benford's Law, providing evidence that markets, at least in the short term, are truly unbiased and that their data are distributed randomly (Ley, 1996).

Benford's Law is also used in detecting tax irregularities. Christian and Gupta (1993) found that taxpayers often reduce their taxable income below the specifications given in the US tax tables (which determines their tax rates and total annual liability). Nigrini (1996) applied the properties of Benford's Law to a dataset on interest received from over 200,000 tax returns between 1985 and 1988. The evidence showed that lower-income taxpayers are more inclined to "invent numbers" on their tax returns than higher-income taxpayers (Nigrini & Mittermaier, 1997: 57).

This brief review of literature shows that the properties of Benford's Law can be used as a random numbers test for datasets in many streams of the social sciences. It also indicates that none of the papers known to the author deals with executive compensation in relation to the properties of Benford's Law. In this paper, we attempt to fill this gap by applying Benford's Law to the executive compensation data from the ExecuComp database. It is our expectation that performance-based or market-determined compensation components will conform to Benford's Law. However, negotiation will blur the random pattern expected in the data. It is therefore unlikely that we will find compensation components that are fully negotiated while also conforming to

Benford's pattern of digit distributions. In the next section, we discuss whether Benford's Law can be used in uncovering the "negotiating power" and "preferences" of top executives, especially CEOs.

### 3 | ANALYTICAL FRAMEWORK AND HYPOTHESES

A CEO compensation package consists of several components—base salary, bonus, and stock options<sup>4</sup> (Jensen & Meckling, 1976; Murphy, 1999). In the Benford's Law framework, the first/second digits of a randomly distributed set of numbers should follow Benford's stylized pattern. Therefore, if we select compensation components from a random distribution, we could expect their leading digits to follow the first/second digit distribution as set by Benford's Law.

The problem of compensation negotiations can also be understood from the perspective of Chamberlin/Robinson-esque "Monopolistic Competition." Here key executives offer their time and capabilities independently to firms for compensation expressed in multiple components. The firms base their trade on limited public and private information about the executives gathered from past associations or during consultations with market participants. Furthermore, previous studies have shown that some components of executive compensation are negotiated while others are based on aspects of firm performance that are essentially market-linked (Bebchuk et al., 2002; Murphy, 1999). This could mean that differences in negotiation among compensation components would ideally reveal a broad spectrum of information about the negotiation process. A market-linked compensation component, for example, would vary in line with the market and behave in a random manner, perfectly emulating the market conditions. Such a component would be expected to closely track the properties of Benford's law. However, compensation components that are not market-linked could be expected to be asymmetric, representing the impact of executives' negotiating powers, and they would not be expected to conform to the expectations of Benford's Law.<sup>5</sup>

Of all the numbers in compensation components, the first two digits are particularly important because they determine size. The first digit of any number varies from "1" to "9", while the second digit ranges from "0" to "9". Psychology literature argues that individuals evaluate numbers sequentially, which only increases the importance of the initial digits of compensation components (Hinrichs et al., 1981; Poltrock & Schwartz, 1984). According to the Jensen and Meckling agency theory (Jensen & Meckling, 1976), executives are particularly focused on negotiating the largest possible (first/second) digit compensation components to maximize their expected pay. In this process, the first digit requires more negotiating power than the subsequent digits, including the second. Therefore, the distribution of the first digit offers the most information about (top) executives' intentions and preferences. However, since the second digit distribution provides some useful knowledge as well, we also included this item in our analysis. In sum, because of its predictive properties and its ability to reveal non-fabricated statistical distributions, Benford's Law is the most suitable instrument for analyzing the first/second digits of compensation components, and uncovering the possible negotiations and preferences of (top) executives. In this context, the marginal increase in

knowledge provided by the information on the subsequent digits (third onwards) of the compensation components are expected to be relatively lower. They are therefore less likely to provide any valuable additional knowledge regarding executives' negotiating power, even though they would still reflect Benford's statistical pattern.

In line with Benford's Law framework, we propose that any type of compensation component which is performance-based or market-determined is randomly distributed. The rationale of this proposition is that CEOs and other top executives will be much less inclined to engage in negotiations or show their preferences as regards their compensation if its size or its starting digits are beyond their control or influence. If this condition is satisfied, performance-based or market-linked compensation components are expected to behave in the same manner as unbiased and randomly distributed datasets. They can thus be expected to conform to the statistical properties of Benford's Law. In this way, Benford's Law becomes a method to test the "unbiasedness" of compensation determined by firm or market performance. Conversely, non-conformity of these performance-based or market-linked compensation components with the expectations of Benford's Law may indicate executive-firm negotiations. Furthermore, as base salary is basically characterized as a negotiated compensation, it will as a rule not conform to Benford's Law either. In this respect, the salary component also reveals another key aspect of compensation negotiation, namely preference.

In this framework the negotiating preferences of executives are the outcome of their negotiating powers. It means that, in order to have their preferences and/or choices regarding first and possibly second digits realized, executives need sufficient negotiating power as a precondition. Therefore, the executives' specific choices regarding the starting digits of their compensation reflect their negotiating preferences.

Following this line of reasoning, the framework offers us two hypotheses that could potentially demonstrate whether Benford's Law is a useful method to test for top executives' negotiations and preferences, especially those of CEOs.

**Hypothesis 1.** *Performance-based or market-linked compensation components conform to the expectations of Benford's law.*

**Hypothesis 2.** *Negotiations reveal executives' preferences.*

### 4 | DATA

The executive compensation data used in this paper were retrieved from the ExecuComp database, maintained by S&P Capital IQ, a McGraw-Hill Financial Inc. company (WRDS, 2015). The S&P Capital IQ database has been tracking the compensation data of the "five top officers" of the firms in the S&P 1500 Index since 1992. We found that, in practice, the number of executives tracked by the database per year per firm varied. The database included many components of compensation, such as salary, bonus, stock options, total compensation, etc. This study analyzed the executive compensation from 1992 up to and including 2014, amounting to 23 years of data for over 3,000 listed firms.

The corresponding accounting data were obtained from the Compustat database and the market data from the CRSP database (only used for robustness checks).

We limited the data sample to firms which have reported on the executive compensation of at least three of their top executives, including the Chief Executive Officer (CEO), for at least five years. In this way, sufficient CEO data could be collected to establish a pattern.

Under these criteria, we yielded a total of 237,585 executive years, with 40,722 CEO years, which is about 17.13 percent of the full sample. Our dataset contained a median of six executives per firm per year, while each firm had existed for at least 13 years. The sample data included firms from all industries.

## 5 | METHODOLOGY

Following the commonly used methodological recommendations in the literature (Carslaw, 1988; Nigrini, 2011), we performed a Z-test to establish whether the executive compensation data, such as salary, bonus, stock options, etc., were in line with Benford's Law. Note that according to Benford, the first and second digits of unbiased datasets are unequally distributed. In the case of our data set, we expected them to follow a specific pattern, as discussed in Section 2.1. Non-compliance of the first two digits with the expectations of Benford's Law would indicate negotiation between the top executives and the firms. The power of the negotiation could be ascertained based on the empirical distance between the actual estimate and expected distribution according to Benford's Law (Benford, 1938).

In this study, we tested both market-determined and negotiated executive compensation components to see if they conformed to the statistical properties of Benford's Law. Our research objective was to determine whether Benford's Law as a method could distinguish between these two types of compensation. If it did, the legitimacy of Benford's Law's would be established, allowing also other aspects of executive compensation to be investigated using this approach.

We calculated the frequencies of the nine values ("1"–"9") for the first digit position and the ten values ("0"–"9") for the second digit position for all compensation components. We then used the Z-statistic formula to see whether the distribution of the first/second digit values were statistically different from the frequencies predicted by Benford's Law. See the Z-statistic test below:

$$Z = \left[ \frac{|p - p_0| - \frac{1}{2n}}{\sqrt{\frac{p_0(1-p_0)}{n}}} \right] \quad (4)$$

Here,  $p$  is the observed empirical frequency of the compensation component;  $p_0$  is Benford's expected frequency for any value in either the first or the second digit position; and  $n$  is the sample size of the digits. The second term in the numerator is  $1/2n$ . The  $1/2n$  is a "continuity correction" term that generally has very little effect on the Z-statistic estimates. When  $n$  becomes too large, it has a tendency to unnecessarily bias the Z-statistic upwards. The continuity correction term is there to deflate the effect of the size of  $n$  as it is also available inside the square root sign. The continuity correction term is used only if it is smaller than  $|p - p_0|$  (Thomas, 1989). The null hypothesis is

rejected at the 10 percent, 5 percent, and 1 percent levels if the Z-statistic exceeds 1.64, 1.96, and 2.57 respectively.

Next, we computed the chi-square statistics to compare whether the actual frequencies or count of the digit values differed from Benford's expectations. The chi-square test ( $\chi^2$ ), where the null hypothesis states that the actual data frequencies follow Benford's Law, is:

$$\chi^2 = \sum_{i=1}^k \frac{(AC-EC)^2}{EC} \quad (5)$$

Here,  $AC$  is the actual count,  $EC$  the expected count and  $k$  is the number of digit values in the first and second digit positions. The summation sign indicates that each of the nine digit values (ten digit values) in first digit position (second digit position) must be added together. The number of degrees of freedom is  $k - 1$ , which means the first digit test has eight degrees of freedom and second digit test has nine degrees of freedom (Nigrini, 2011).

## 6 | EMPIRICAL ANALYSIS

### 6.1 | Compensation variables of interest

In this section, we first describe the five types of executive compensation components used in this study, namely: (i) Salary, (ii) Bonus, (iii) Option Award, (iv) Option Fair Value, and (v) Total Compensation.

As Salary (ExecuComp: "salary") is a primary compensation, we expected the executives to have a significant bargaining space here. We therefore considered Salary as a negotiated compensation.

Bonus (ExecuComp: "bonus") is a significant portion of the total compensation of top executives. Since the firm's short-term accounting performance is a key determinant of Bonus, we considered it a performance-based compensation.

Option Award (ExecuComp: "option\_awards\_num") is the number of stock options awarded to an executive in any given year. Although this form of compensation is also performance-based, the negotiating skills of executives can play a significant role in determining the number of options awarded to them. Therefore, we do not make *ex-ante* assumptions about the "negotiability" of this variable.

Option Fair Value (ExecuComp: "option\_awards\_fv") is the fair value of the stock options awarded to an executive in a particular year. The dollar amount of the Option Fair Value cannot be directly negotiated by the executive as it depends on the value of the stock options on the grant date, which is market-determined.<sup>7</sup> Therefore, we predict that this variable behaves randomly.

Lastly, we also included both values of Total Compensations (ExecuComp: "tdc1" and "tdc2"). Here, "tdc1" represents Total Compensation1, the sum of all dollar values including the stock options at the grant date, and "tdc2" Total Compensation2, which is the sum of the dollar value of the compensation components, including the stock options, when exercised.

### 6.2 | Summary statistics

As briefly mentioned earlier, our sample dataset covered the period 1992–2014. Because ExecuComp started maintaining the

compensation data of US publicly listed firms in 1992, that is our first sample year. Table 2, Panel A, provides the annual median values of Executives per year, Total executives per year, Total number of CEOs per year, Salary, Bonus, Option Award, Option Fair Value, Total Compensation1 and Total Compensation2. Panel B of Table 2 shows the time series averages of these variables.

Our sample dataset included on average 5.6 executives per firm, per year. In total, we had on average over 10,000 executives per year, among whom about 1,770 were CEOs in each year. The executives' (including the CEOs) Salary was on average \$359,000 during our sample time period, while they additionally received \$162,000 as Bonus component. The Option Awards they received during this time included an average amount of over \$46,000. When allotted, the executives' estimated value of stock options (Option Fair Value), valued using the Black/Scholes model, was found to be \$500,000, starting 2006. When calculating the total compensation including the stock

option values (when Options allotted), we concluded that during our sample period the executives earned a little over \$1.4 million. However, this value is a little lower at \$1.3 million when the total compensation is calculated using the value of stock options when exercised.

### 6.3 | Can Benford's Law explain CEO pay?

In this section, we analyze the evidence to see whether Benford's Law can determine the difference between performance-based or market-determined pay and negotiated compensation. If this difference can be discerned using Benford's Law, its empirical validity in the executive compensation literature is verified.

Table 3 shows the first/second digit ( $p - p_0$ ) deviation estimates, the corresponding Z-statistics and the chi-square values of the main CEO compensation components Salary, Bonus, Option Award, Option Fair Value, Total Compensation1, and Total Compensation2. The

**TABLE 2** Summary statistics

Panel A: Annual median values									
Year	Exec./yr.	Tot. exec./yr.	Total CEO/yr.	Salary	Bonus	Option Award	Option Fair value	Tot. Comp. 1	Tot. Comp. 2
1992	5	7,320	1,407	241.42	113.85	20.00		605.64	490.69
1993	6	8,969	1,513	244.75	117.17	21.40		627.29	523.71
1994	6	9,952	1,604	254.34	135.25	22.33		699.58	525.35
1995	6	10,638	1,738	260.78	146.16	27.00		728.20	578.77
1996	6	11,320	1,887	270.34	155.42	32.67		857.24	617.98
1997	6	11,604	1,925	274.88	167.36	39.00		969.26	717.95
1998	6	12,192	1,969	286.11	161.25	45.72		1,027.05	740.58
1999	6	11,900	1,887	297.99	184.89	54.17		1,209.13	803.62
2000	6	11,377	1,811	312.11	197.97	61.00		1,365.05	966.74
2001	6	11,292	1,824	321.78	175.94	64.13		1,348.54	875.75
2002	6	11,458	1,859	336.34	207.94	60.71		1,334.04	874.74
2003	6	11,640	1,887	347.44	230.76	53.75		1,261.27	999.67
2004	6	10,749	1,841	365.94	293.33	53.77		1,527.88	1,392.29
2005	5	9,275	1,733	400.56	340.03	52.50		1,633.70	1,692.79
2006	5	10,739	1,877	393.79	120.25	44.55	472.10	1,597.44	1,839.53
2007	6	11,450	1,988	400.57	71.43	44.91	472.86	1,596.03	1,811.29
2008	6	10,903	1,896	420.37	75.67	52.64	467.78	1,597.45	1,520.83
2009	5	10,286	1,842	431.69	78.36	68.01	418.55	1,540.85	1,419.02
2010	5	9,766	1,802	448.73	83.33	53.44	491.40	1,925.20	1,907.88
2011	5	8,434	1,606	473.11	85.00	48.17	518.85	2,088.66	2,165.99
2012	5	9,252	1,673	479.26	178.97	54.00	535.38	2,104.28	2,257.29
2013	5	8,847	1,607	491.40	200.00	51.97	579.58	2,319.52	2,517.07
2014	5	8,222	1,546	513.62	205.87	45.81	547.95	2,531.41	2,674.76
Panel B: Time series averages									
Ann. avg.	5.61	10,329.78	1770.52	359.45	162.01	46.59	500.49	1,412.81	1,300.62
Std. dev.	0.50	1,339.16	157.27	86.97	68.53	13.67	49.37	540.55	690.47
Min.	5	7,320	1,407	241.42	71.43	20.00	418.55	605.64	490.69
Max.	6	12,192	1,988	513.62	340.03	68.01	579.58	2,531.41	2,674.76
¼ Percentile	5	9,263.5	1,640	280.50	115.51	41.77	472.10	998.16	729.26
¾ Percentile	6	11,413.5	1,887	426.03	198.99	53.89	535.38	1,615.57	1,825.41

Notes: In this table, we report the distribution of Executives (incl. CEOs) over the years with key compensation variables. Exec./yr is the median number of executives per firm per year (incl. CEO). Tot. exec./yr. gives the total executives per year (incl. CEO). Tot. CEO/yr. gives the total CEO per year. Salary, Bonus, Option Award, Option Fair Value, Total Comp. 1 and Tot. Comp. 2 give the median of the variables, per firm per year. Panel B gives the time series averages, standard deviations, minimum, maximum, ¼ percentile and ¾ percentile values.

( $p - p_0$ ) value, or “deviation” estimate, is the difference between the empirical frequency of a digit value in the sample data and the expected pattern according to Benford's Law. The corresponding Z-statistic/chi-square statistic tests the statistical significance of the deviation.

Option Fair Value represents the dollar value outcome of the stock options when granted by the firms to their CEOs. According to the Jensen and Meckling (1976) agency theory, a maximum compensation would contain stock options with the largest fair value, implying an amount based on the highest first/second digits. However, CEOs generally do not negotiate the dollar value of the options, but the number of options awarded to them. However, even this point of departure is potentially uncertain. From Table 3 Panels A and B, it follows that almost all first and second digit deviations reported for Option Fair Value are too small to be statistically significant according to the Z-statistics. Of the nine first digit values, only one is statistically significant at a 1 percent level. Since there is no overall trend in the estimates, the slight overestimation of digit value “7” at the first digit position could simply be attributed to the large sample size (7,940). This explanation is further supported by the chi-square statistic ( $\chi^2$ ), which is statistically insignificant at 0.23. In his book on Benford's Law and its applications, Nigrini (2011) notes that the Z-statistic tends to overshoot the statistical significance, especially for small differences when the samples are fairly large. Therefore, we could conclude that, overall, there is no sign of CEO negotiations about the fair value dollar amount of the stock options.

As expected, none of the first or second digit value frequency deviations of Salary ( $p - p_0$ ), a component known as directly negotiated (Murphy, 1999), were found to follow the expectations of Benford's Law. The ( $p - p_0$ ) estimates show that the larger values are significant and positive, which means that the highest digit “9” occurs 2.93 percent (Z-value = 20.95) more than it would according to Benford's expectations. Furthermore, smaller digits such as “1” (–12.32 percent, Z-value = 53.93) and “2” (–9.52 percent, Z-value = 50.17) are underrepresented in the frequency distribution. This evidence, therefore, not only confirms that Salary is closely negotiated, thereby providing legitimacy to Benford's Law, but it also reveals how top executives bargain harder for larger compensation. They do this by negotiating larger first digit values while avoiding smaller values. Given these two pieces of evidence, we could conclude that there is support for Hypothesis 1, that performance-determined or market-linked compensation conforms to Benford's Law, whereas negotiated compensation does not.

Bonus and Option Awards are performance-based incentives, and if we accept the principals of agency theory (Jensen & Meckling, 1976; Jensen & Murphy, 1990a; Murphy, 1999), these compensations should be paid based on merit. However, agency theory has been known to have a fairly poor record when it comes to empirical literature (Hall & Liebman, 1998). It is therefore conceivable that some aspects of these compensations are negotiated after all. As far as CEOs are concerned, their focus is on the biggest compensation based on the highest digit values. From the frequency deviations reported in Panels A and B of Table 3 for the first and second digits respectively, it becomes clear that both Bonus and Option Award have a mixed record. For Bonus, some of the first digit lower mid-values, such as “2” (–0.16 percent, Z-value = 0.64) and “3” (0.17 percent, Z-value = 0.77) and higher

mid-values such as “6” (0.14 percent, Z-value = 0.82) and “7” (0.06 percent, Z-value = 0.38) conform to the expectations of Benford's Law, as they are statistically insignificant. The values “1” (–0.76 percent, Z-value = 2.54), “8” (–0.50 percent, Z-value = 3.44) and “9” (–0.60 percent, Z-value = 4.42) are not in line with this pattern as they are statistically significant. We observe a similar trend for the first digit mid-values for Option Award. In both cases, however, the outlier is the mid-value digit “5”. The first digit value “5” for Bonus and Option Award is uncharacteristically large and positive. For Bonus, “5” is overrepresented by 1.17 percent (Z-value = 6.65) and for Option Award by 1.53 percent (Z-value = 9.13). In the second digit, “5” is overestimated for Bonus by 4.08 percent (Z-value = 21.04) while for Option Award it is no less than 7.67 percent (Z-value = 41.29). What we find here is an unusual demand for “5” as first and second digit values. This result not only reinforces the assumption that some aspects of the Bonus and Option Award are negotiated, but the specific and unusual demand for value “5” also reflects negotiating “preference”. It means that, when exercising their negotiating power, some executives have a preference for “5” as first digit over any other value. In the second digit position, the overrepresentation of the value “0” is not surprising, given that previous studies on rounding-off have found similar evidence (Thomas, 1989). Here, however, it could be interpreted as marginal negotiations regarding later values. All in all, we find support for our Hypothesis 2, that negotiating power is associated with a preference for round figures and, in particular, digit values such as “5”.

However, there is always the possibility that the over- or underrepresentation of first/second digit values are just coincidental. In other words, the specific overrepresentation of larger and specific digit values such as “5” are perhaps not the outcome of negotiations, but may instead be attributed to chance. We analyzed this question using the first/second digit frequency deviations of the two types of Total Compensation as reported in Table 3. Panels A and B indicate the first and second digit deviation ( $p - p_0$ ) estimates along with the Z-statistics and chi-square values of Total Compensation1 (Total Comp1) and Total Compensation2 (Total Comp2). Total Comp1 is the sum of all compensation components including the dollar value of stock options *estimated at the grant date*. Total Comp2, however, is the sum of all compensation components including the stock option values *when finally exercised by the executives*. In a Jensen and Meckling (1976) type of agency model, we expect the agents to maximize their compensation by negotiating the largest digit values. Ideally, therefore, they should be focused the most on their Total Compensation, which ultimately values the final rent extracted by the CEO from their association with the firm. Looking at the frequency deviations, it is quite clear that even though some digit values are over- or underrepresented, there is no real pattern. At the first digit position, the higher value digits are at best only slightly overrepresented. However, the statistical significance is so small for these large sample sizes (39,630 for Total Comp1 and 40,480 for Total Comp2) that it could easily be assigned to an upward bias in the statistical significance test, as highlighted by Nigrini (2011). This lack of pattern is particularly emphasized by second digit values such as “5”, which are not significant at all, and “0”, which is barely significant, given the large sample size. This apparent lack of interest in Total Compensations on the part of the executives could be explained by the non-negotiability of this item.

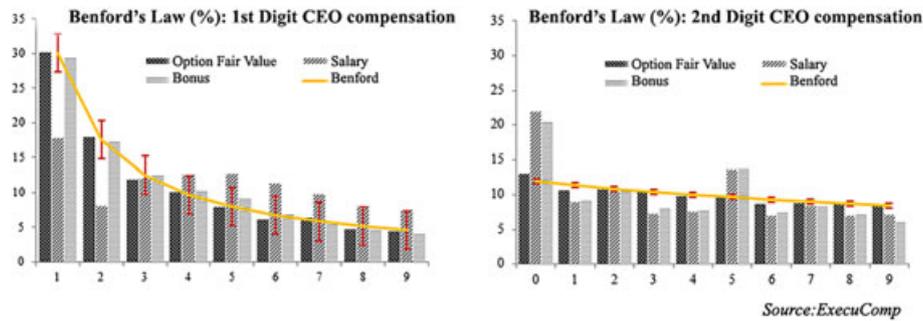
**TABLE 3** Empirical results using Benford's Law

Panel A: First digit deviations and their Z-statistics													
1st Dig.	Exp. $p_0$	Salary		Bonus		Option Award		Option Fair Value		Total Comp1		Total Comp2	
		Dev.( $p-p_0$ )	Z-stat.	Dev.( $p-p_0$ )	Z-stat.	Dev.( $p-p_0$ )	Z-stat.	Dev.( $p-p_0$ )	Z-stat.	Dev.( $p-p_0$ )	Z-stat.	Dev.( $p-p_0$ )	Z-stat.
1	30.1	-12.32	53.93	-0.76	2.54	1.04	3.66	0.11	0.21	0.01	0.03	-0.50	2.19
2	17.61	-9.52	50.17	-0.16	0.64	0.06	0.25	0.31	0.71	-0.99	5.19	-1.56	8.23
3	12.49	-0.49	2.97	0.17	0.77	-0.12	0.59	-0.54	1.43	-0.40	2.43	-0.38	2.29
4	9.69	2.87	19.49	0.49	2.52	-0.69	3.73	0.47	1.38	0.23	1.53	0.34	2.31
5	7.92	4.89	36.36	1.17	6.65	1.53	9.13	0.01	0.00	0.30	2.20	0.35	2.62
6	6.69	4.63	37.21	0.14	0.82	-0.27	1.73	-0.51	1.79	0.12	0.95	0.55	4.42
7	5.8	4.04	34.69	0.06	0.38	0.36	2.45	0.58	2.17	0.27	2.26	0.45	3.89
8	5.12	2.97	27.03	-0.50	3.44	-0.69	5.05	-0.31	1.25	0.20	1.78	0.55	5.03
9	4.58	2.93	28.11	-0.60	4.42	-1.22	9.40	-0.12	0.46	0.28	2.62	0.19	1.81
N		40.31 T		23.47 T		25.89 T		7.94 T		39.63 T		40.48 T	
$\chi^2$		0.00		0.00		0.00		0.23		0.00		0.00	

Panel B: Second digit deviations and their Z-statistics													
2nd Dig.	Exp. $p_0$	Salary		Bonus		Option Award		Option Fair Value		Total Comp1		Total Comp2	
		Dev.( $p-p_0$ )	Z-stat.	Dev.( $p-p_0$ )	Z-stat.	Dev.( $p-p_0$ )	Z-stat.	Dev.( $p-p_0$ )	Z-stat.	Dev.( $p-p_0$ )	Z-stat.	Dev.( $p-p_0$ )	Z-stat.
0	11.97	10.01	61.91	8.64	40.62	21.48	105.32	1.08	2.94	0.56	3.43	0.86	5.32
1	11.39	-2.31	14.61	-2.09	10.02	-5.07	25.41	-0.63	1.74	0.05	0.33	0.08	0.51
2	10.88	-0.33	2.13	0.09	0.42	-1.15	5.85	0.02	0.04	0.19	1.24	0.18	1.19
3	10.43	-3.06	20.09	-2.24	11.20	-4.20	21.85	0.19	0.54	-0.07	0.45	-0.24	1.60
4	10.03	-2.47	16.48	-2.33	11.80	-4.35	23.06	-0.10	0.28	-0.30	1.97	-0.47	3.14
5	9.67	4.03	27.37	4.08	21.04	7.67	41.29	0.14	0.42	-0.06	0.37	0.22	1.50
6	9.34	-2.22	15.31	-1.66	8.68	-3.55	19.42	-0.65	1.97	-0.12	0.78	-0.25	1.73
7	9.04	-0.57	3.97	-0.64	3.42	-2.77	15.35	-0.10	0.28	-0.03	0.22	-0.25	1.77
8	8.76	-1.78	12.61	-1.55	8.33	-3.63	20.41	-0.06	0.16	-0.13	0.88	0.00	0.00
9	8.5	-1.31	9.45	-2.31	12.64	-4.44	25.33	0.09	0.26	-0.12	0.85	-0.14	0.99
N		40.29		23.29		25.35		7.92		39.62		40.47	
$\chi^2$		0.00		0.00		0.00		0.00		0.05		0.00	

Notes: In Panel A, we tabulate the first digit deviations ( $p - p_0$ ) and Z-statistics of six compensation components of the CEOs—Salary, Bonus, Option Award, Option Fair Value, Total Compensation1 and Total Compensation2. Panel B records second digit deviations of the CEO compensation components with Z-statistics. "Exp." is Benford's expected pattern. "Dev." is the ( $p - p_0$ ) deviations from Benford's expectations (all Dev. values are in %). N is the number of data-points (in thousands). The Z-statistics are significant at 10%, 5% and 1% levels if the value exceeds 1.64, 1.96 and 2.57, respectively



**FIGURE 1** CEOs compensation—Option Fair Value vs. Salary vs. Bonus

Negotiation between the executive and the firm typically relates to other aspects of the compensation, and the final outcome, such as the Total Compensation, is just an honest summation of all remaining components, resulting in a quasi-unbiased dataset. This evidence supports our earlier inferences that certain compensations are negotiated and other items are largely market-determined.

To illustrate the difference between a negotiated compensation—such as Salary—and a market-determined component—such as Option Fair Value—more plainly, we present a graphical representation in Figure 1. The figure is divided into two parts. The first part reflects Benford's distribution for the first digit, and the second part shows Benford's distribution for the second digit, both represented by a line graph. The first and second digit values of Option Fair Value neatly track Benford's expected pattern and stay within the 5 percent deviation band. However, for Salary, we can see that the lower value digits are underrepresented, i.e. they fall below the values expected by Benford's Law, while the higher values are overrepresented, which means that they remain above the line graph. We interpret these aberrations using Benford's expectations as CEO negotiating power. Bonus, however, stays close to Benford's distribution, except for some minor deviations as reported in Table 3. This graph succinctly illustrates the evidence found in support of Hypothesis 1, i.e. market-based compensation follows Benford's Law.

In the second half of the graph, for Salary, the second digit values “5” and “0” are clearly overrepresented compared to Benford's criteria. This result is evidence in support of Hypothesis 2, arguing that through their negotiating power, CEOs show their preferences for certain starting digits in their compensation. This evidence is especially obvious for Bonus, because in the first digit position, most values stick closely to Benford's expectations. This could only mean that top managers, such as CEOs, have a greater negotiation leverage when it comes to the second digit values. They use this leverage by showing their preference for “5” or marginally higher third digits, resulting in an overrepresentation of “0” in the second digit place. This inference is strengthened by the graphical representation of the Option Fair Value, which closely follows Benford's second digit expectations, confirming our previous findings.

## 6.4 | Some other applications of Benford's Law using CEO pay data

We have now established the utility of Benford's Law in the analysis of executive compensation. To demonstrate its usage in some new and creative ways, this section provides some additional analysis of three

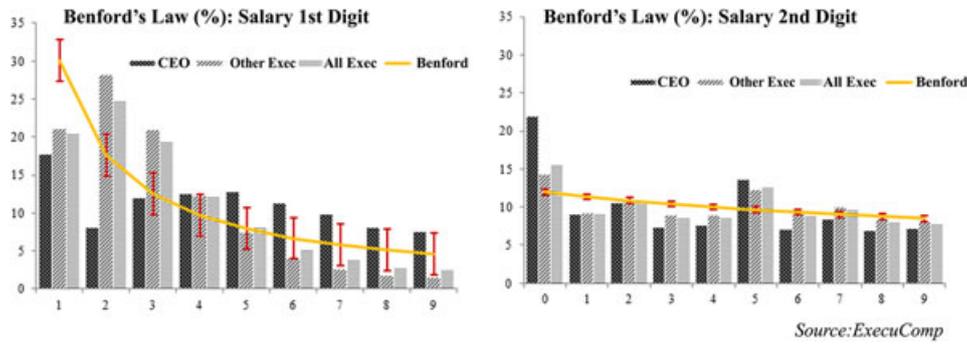
well-known problems. In this section, in essence, we want to show how Benford's Law could be used in sorting and re-sorting compensation data to study the impact of negotiations.

### 6.4.1 | CEO negotiation power vs. that of Other Executives

The rise of gross CEO compensation without any convincing correlation to firm performance (Hall & Liebman, 1998; Jensen & Murphy, 1990b) has been considered as an undesirable development. Academics have not been able to explain this issue using the standard Jensen and Meckling (1976) agency model. Another attempt to explain this problem was made by applying the Tournament theory (O'Reilly et al., 1988) and the Managerial Power theory (Bebchuk et al., 2002; 2011; Bratton, 2005). If CEOs are, on average, the “winners” in a corporate hierarchical “tournament”, it would be conceivable that they possess considerably more “power” in the negotiation of their compensation than the “losers” in the tournament, the executives lower in the food chain (Bebchuk et al., 2011). We therefore posed the following question: Are CEOs in a better position to negotiate some of their compensation components than non-CEO “Other Executives?” We tested this hypothesis using Benford's Law.

We divided our dataset between “CEOs” and “Other Executives” using the “ceoann” field found in the ExecuComp dataset.<sup>8</sup> We compared these data with the “titleann” column of the database to ensure accuracy. In the case of a mid-year CEO change, we retained the old CEO for that particular year as his/her policy would still be effective. The “All Executives” data were also retained; this variable was nothing more than the sum of the CEOs and Other Executives, used simply for the sake of a benchmark comparison. Our results are shown in the two-part graphical representation in Figure 2. It shows the frequencies of the first and second digit values of the Salary component. Now that we have established that Benford's Law can be used as a method to distinguish negotiated compensations from market-determined ones, we are able to use the first category to test our hypothesis. To see whether Benford's Law can be used in revealing a possible difference in negotiating power, we present an analysis of the component “Salary”.

The first half of Figure 2 reports the first digit distribution of CEO Salary, Other Executives Salary, and All Executives Salary. The second half shows the second digit distribution of the same data. The first half of Figure 2 shows that, for CEOs, all large value digits (greater than “4”) are overrepresented (positive and statistically significant), and that for Other Executives the evidence is the opposite. For Other Executives



**FIGURE 2** CEOs, other executives and all executives (including CEOs)—Salary

almost all large values are underrepresented (i.e. negative and significant). This evidence provides support for the hypothesis that CEOs prefer more compensation and not less, and that their negotiation power is superior to that of Other Executives. The second half of Figure 2 indicates that all executives prefer the round figures “5” and “0”. However, CEOs are still overrepresented here, which lends support to the hypothesis that because they are the “winners” of their hierarchical “tournament”, they are in a better position to negotiate a bigger compensation.

**6.4.2 | Before and after the Sarbanes-Oxley Act**

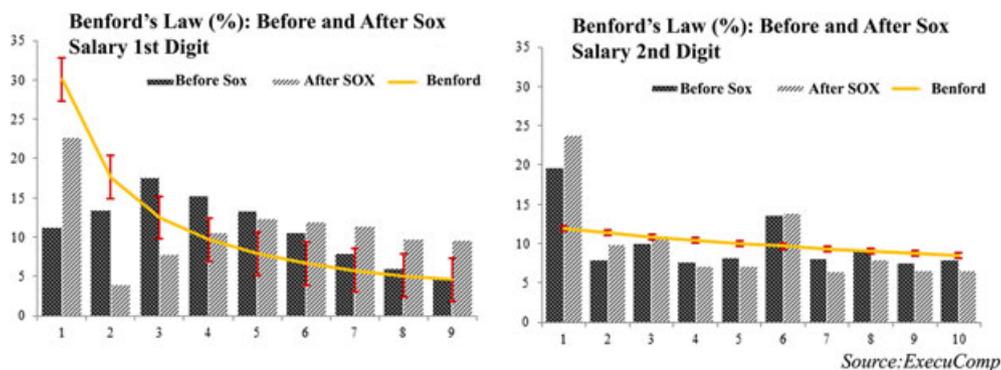
The Sarbanes-Oxley Act (or SOX) (2002) has had a huge impact on the information environment. It has required companies to disclose much more information on issues such as executive compensation than before its introduction (Lee, Strong, & Zhu, 2014). It has been the lawmakers' objective to curtail the levels of earnings management and improve corporate governance mechanisms (Aono & Guan, 2008; Heron & Lie, 2007). One of the principal provisions of SOX regarding executive compensation relates to the mandatory reporting within two days of stock transactions by board members, officers and investors who own more than 10 percent of the company's stocks. A study by Heron and Lie (2007) shows that the mandatory disclosure requirements as introduced by SOX have indeed reduced the power of executives. If this is the case, what impact could these measures have on the compensation negotiations? In this section, we explore whether, on the basis of Benford's Law, any discernible differences can be observed in the negotiating tactics of CEOs, before versus after SOX.

We divided the full time-period into two segments: before SOX, and after its implementation starting 2003. Figure 3 reports the first and second digit distributions of CEO Salary before and after SOX.

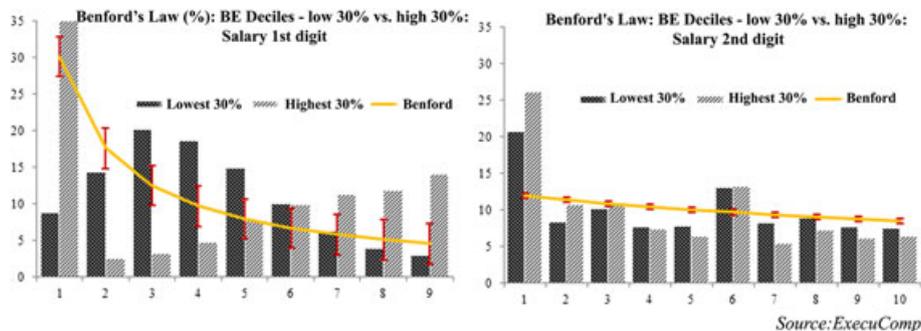
Examining the first digit values of Salary in the first half of Figure 3, it becomes clear that the change in regulatory regime indeed resulted in differences regarding CEO negotiations. Before SOX, CEOs seemed content with a Salary with a smaller starting value, such as “3” or “4”. After SOX, CEOs have been found to negotiate salaries with larger first digit values, such as “6”, “7”, “8”, or “9”, which could considerably increase the compensation size. This evidence supports the hypothesis that SOX has changed the way in which top executives negotiate their compensation. It is an important finding, as it provides some clues to future researchers where to look in studying CEO's negotiating tactics. Heron and Lie (2007) found that post-SOX there has been a decline in CEO manipulation techniques, such as the backdating of stock options. Our evidence indicates that post-SOX CEOs negotiate a larger value of their Salary compensation to hedge against the risk of lower wages. At the same time we see that post-SOX their manipulation power with respect to the negotiation of variable compensations such as Bonus and Options Awards has clearly decreased, an outcome of the enhanced disclosure requirements. Also the estimates of the second digit values of post-SOX Salary in the second half of Figure 3 indicate that nowadays CEOs increasingly focus on round figures, yet another technique to hedge against wage variability risks.

**6.4.3 | Firm size**

A firm's size is an important determinant of CEO executive compensation (Kostiuk, 1990). Large firms often have powerful, influential, and sometimes flamboyant CEOs, who demand large compensation. But do big-firm CEOs negotiate their compensations differently than small-firm CEOs? In answering this question we again applied Benford's Law. We used two different variables to determine a firm's size: the book value of equity (BE) as found in the Compustat database



**FIGURE 3** Before vs. after SOX—Salary



**FIGURE 4** Firm size—Salary

(Compustat: #CEQ—Common/Ordinary Equity—Total) and the market equity (ME), estimated based on the market data from the CRSP database. As both estimates are practically identical, we only report BE (see Figure 4) in this study. We applied the one-year lagged values of BE and made a yearly categorization of the firms into three portfolios, small (size below 30 percent deciles), medium (size between 31 and 69 percent deciles) and large (size larger than 70 percent deciles). Figure 4 shows the first and second digit distributions of CEO Salary for the “small” and “large” BE portfolios together with Benford's expected patterns. The estimates are separately calculated for the different portfolios using the one-year lagged BE.<sup>9</sup>

The first half of Figure 4 shows a difference in Salary negotiation between CEOs of “small” and CEOs of “large” firms. We see that CEOs of small firms (lowest 30 percent deciles) are overrepresented for Salary with small first digit values such as “3”, “4”, and “5”. CEOs of large firms (highest 30 percent deciles) are overrepresented for Salary starting with first digit values such as “6”, “7”, “8”, and “9”. The only exception is “1”, where small firm CEOs are underrepresented and large firm CEOs overrepresented. This result could indicate that large firm CEOs are also better capable of negotiating the second digit, as shown in the second half of Figure 4. The overrepresentation of the second digit value “0” results in a large distribution of the first digit value “1”. This evidence shows that apart from negotiating their fixed compensation differently, large firm CEOs also behave as predicted by the Jensen and Meckling (1976) agency model, namely as compensation maximizing agents.

## 7 | CONCLUSIONS AND LIMITATIONS

In this study, we contributed to the corporate governance literature by proposing the usage of Benford's Law in explaining CEO pay. In the first part of the analysis, we established that Benford's Law is a suitable method for differentiating between performance-based or market-linked pay and directly negotiated compensation. Having proven its effectiveness, we next proposed the usage of Benford's Law in testing some interesting executive compensation-related problems. In the second part of our empirical study we therefore applied Benford's Law to shed light on three specifically related issues, namely (1) Is there a difference between the compensation negotiating powers of CEOs and those of Other Executives?; (2) Is there a difference between the compensation negotiating tactics of CEOs before and after the implementation of SOX; and (3) Is

there a difference between small-firm CEOs and large-firm CEOs in the way in which they negotiate their fixed compensation? The evidence from our analysis using Benford's law showed that there is indeed a difference in negotiating power between CEOs and Other Executives. It clearly skews in favor of CEOs. Next, we found that the implementation of SOX made a decisive impact on the way in which CEOs negotiate their fixed compensation, indicating a higher composition of fixed pay, as a risk-hedging technique. And finally, we found that CEOs from small firms are clearly disadvantaged in the way in which they negotiate their pay. The most striking result of our study is, however, that all executives, including CEOs, like to be paid in round figures such as “0” in the second digit positions, and that the first/second digit value “5” is also especially popular.

By introducing Benford's Law, this study has added an important new tool to the literature on corporate governance in general and executive compensation in particular. Furthermore, it has broadened our insight into the compensation negotiating power and preferences of (top) executives, especially CEOs.

This study is not without its limitations. First of all, we want to stress that our proposed method of analyzing the negotiating power of executives does not in any way invalidate the application of other robust approaches in studying the interactions between managers and firms. And although Benford's Law could serve as an independent confirmatory method, a potential shortcoming is that it does not control for independent variables which could affect CEO pay. The advantage is, however, that it is size-independent. In conclusion, therefore, we could safely suggest that this method could be a useful instrument for academics, regulators, and consultants in investigating several pay-related issues, such as the negotiating behavior and preferences of managers and CEOs, executive compensation in small and big firms, or the differences among entire industries as regards these topics. However, in order to reach any concrete conclusions about these matters, we strongly recommend using Benford's Law in combination with additional research methods.

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## ENDNOTES

- <sup>1</sup> This paper does not dwell upon the reason for the hierarchical oversight in the nomenclature of the "Law" as that is outside the scope of this study.
- <sup>2</sup> The evolution of Benford's Law is not dissimilar to that of the Gaussian normal distribution. Although the idea of the now ubiquitous "bell curve" of a normal distribution first originated in the writings of Abraham de Moivre and was later published in *Miscellanea Analytica* in 1733, formal proof of the "central limit theorem" can be found in Jacob Bernoulli's path-breaking analysis in *Ars Conjectandi*, published in 1713. However, neither the application of the curve-fitting normal distribution nor its mathematical properties were known until the English scientist Francis Galton used them to study the heights of parents and their offspring in his book *Natural Inheritance*, which was published no earlier than in 1889. For more on the history of the normal distribution, see the work of Patel and Read (1982).
- <sup>3</sup> Creative applications of Benford's Law are found in connection with religious data (Makous, 2011; Mir, 2012), election frauds (Leemann & Bochler, 2014), population studies (Sandron, 2002), auctions on eBay (Giles, 2007), survey data (Judge & Schechter, 2009), tax data (Nigrini, 1996), economic data (EU) (Michalski & Stoltz, 2013), Libor manipulations (Abrantes-Metz et al., 2012), accounting fraud detection (Nigrini, 1999), and financial reporting (McGuire, Omer, & Sharp, 2011). For a detailed list of useful application of Benford's Law, see Hürlimann (2006).
- <sup>4</sup> We consciously excluded long-term retirement benefit plans from our analysis because of their statutory nature and low predictive ability with respect to CEO negotiations and preferences.
- <sup>5</sup> We thank one of the anonymous reviewers for the kind feedback that resulted in developing the theoretical arguments which could connect the negotiations of the executives with the expectations of Benford's Law.
- <sup>6</sup> For more information, see Nigrini (2011: 110).
- <sup>7</sup> The firms estimate the fair value of options on the grant date in accordance with the FAS 123R accounting standard, published in 2004.
- <sup>8</sup> In a similar way, the dataset could be further divided into subfactors to study the impact of other presumably omitted variables.
- <sup>9</sup> Although the size estimate "ME portfolios" has not been reported, we have calculated it at the close of December in the year  $y - 1$  as share outstanding  $\times$  stock price using market data from the CRSP database.

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