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FOREIGN TRUST AND CONFIDENCE IN PHILIPPINE STOCKS USING BENFORD'S LAW

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ABSTRACT

Benford's Law (BL) was discovered separately by Simon Newcomb in 1881 and Frank Benford in 1938. The law states that naturally occurring numbers do not have an equal chance of happening. Lower digits occur more frequently that do the higher digits. Such distribution properties extend valuable usefulness in assessing the quality of number sets. This work utilized the law to assess the foreign investors' confidence in Philippine stock market, working on the null that the volatility of net foreign buys of stocks should not depart from the BL pattern.

Employing chi-squared and ordinary least squares methods, this study found that the data set conforms to Benford's Law at 99% level of confidence, lending some evidence that the volatility of foreign buys of Philippine stocks stays at a stable level, which is interpreted as foreign investors' confidence and trust in the focal market.

KEYWORDS: Benford's Law, Volatility, Investor Confidence, Stock Market, Philippine Stock Exchange

INTRODUCTION

A Short History

Common intuition tells that numbers or numerical digits that exist in reality happen at random, and thus they each have an equal chance of occurring. However, Simon Newcomb thinks otherwise based on his discovery and published work "*Note on the Frequency of Use of the Different Digits in Natural Numbers"* in 1881 (Endress, 2014). In 1938, Frank Benford, after whose name the law became famous, separately discovered that lower digits occur more frequently than higher digits. He published this observation in*" The Law of Anomalous Numbers"* (Lynch,2008; Li et al., 2015), backing it up with test results on, among others, surface areas of rivers, heat and molecular weights, street addresses and entries on math books (Hill,1995). Many scholars, after having been introduced to Benford's Law (BL), contributed their effort for its better understanding such as its scale-invariance property (Pinkham, 1961) and base-invariance property (Hill, 1995).

In 1984, Mark Nigrini demonstrated its power to detect anomalies, calling it digital analysis. Since then, BL found its way in areas where it could be useful. This work is pursued along that spirit, intending to use it to evaluate foreign investors' confidence in Philippine stock market through the assessment of the daily foreign stock buys report. It may benefit foreign and domestic analysts, current and prospective investors, and academicians.

The 1st Digit Benford's Law (1BL)

According to the 1BL, the first digits of numbers follow a distribution where the lower digits occur more frequently than do the higher digits, that is, the lower digits have greater probability of occurrence than the higher digits. More formally, it is given by:

$$P_d = log_{10}\left(1+\frac{1}{d}\right); for\ d = 1,\ldots,9 \quad (1)$$

$$= log_{10}(1+d^{-1}); for\ d = 1,\ldots,9 \quad (2)$$

Figure 1 shows a monotonically decreasing curve (Lee et al., 2010) with the corresponding frequency values computed from either (1) or (2).

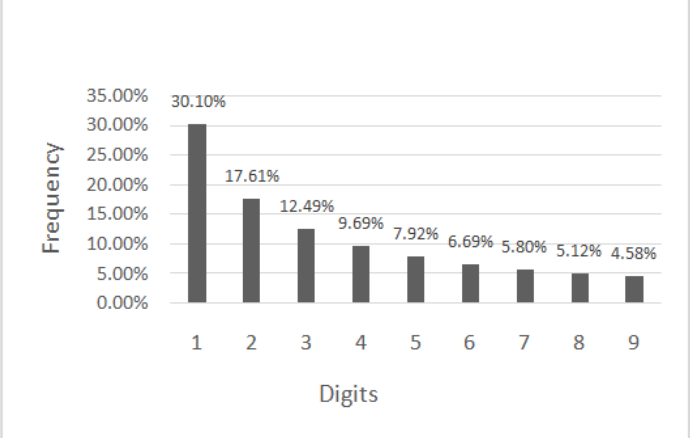

Figure 1: Benford's Law

LITERATURE REVIEW AND HYPOTHESIS

Benford's Law in Various fields

BL has been and continues to be of benefit to a vast array of human endeavor. For example, in instrumentation and signaling, BL was utilized to form a model that distinguishes noise from information (Li et al., 2015). In accounting and finance, Amiram et al. (2015) pioneered the application of BL test on financial statement (FS) line items. Quite a number also made use of BL to investigate some facets of the stock market. Ley (1996) studied the stock return and found BL conformance at 10-100% return range. Chun-khai (2012) used Benford's Law to measure trading volume volatility. Karavardar (2014) studied the Istanbul stock market, employing Benford's Law. By using monthly gains and losses using two currencies as base, he found that returns conform to BL, suggesting that the market data is free of unnatural contamination. In computing, Endress (2014) analyzed auction prices available in a virtual game, and found that prices taken individually are not related but as a whole conform to BL.

Philippine Stock Exchange

On its website, the Philippine Stock Exchange (PSE, 2016) recounts its birth from the Makati Stock Exchange and Manila Stock Exchange in 1992. It initiated its modernization with its computerization in 1993, followed by its one price-one market slogan in 1994, events which were reinforced by Philippine Securities and Exchange Commission's (SEC) granting it a self-regulatory organization status that allows it to frame its own policy and sanction its erring members. The year 2005 marked an ever stronger push towards modernization, with its adoption of online daily disclosure system (ODiSy) and PSE trade in 2010 that replaced Maktrade software of 1995. Finally, in 2013, the development of Electronic Disclosure Generation Technology (EDGE) signaled PSE's commitment to stay at the forefront of modern stock trading. At a float adjusted market capitalization of PhP 3,373,124,828,070.53 (USD 72.5 billion) as of June 13, 2016, Philippine

stock market is undeniably an attractive hunting grown for profit. The PSE index (PSEi), composed of 30 blue chips, is the best approximation of the stock market (PSE, 2016)

Hypothesis

Trust or confidence between transacting parties is very important in the conduct of business. It never fails to draw interest, be it in its attitudinal-behavioral aspect (Ashnai et al., 2016), as a factor of operational performance (Shi and Liao, 2015), or its influence on tax compliance (Gobena and Van Dijke, 2016). In investing, it also plays a vital role since investors place their money where their trust is. Generally, they gravitate toward trusted assets or portfolio of assets and quite obviously, the reverse is also true. When investors decide to invest in an asset, words are not needed to express how much they trust the asset, and by extension, the players that may have a direct or indirect influence on the outcome of their exposure. Similar to what directional buyers or sellers are in stock market or options market (Kang and Park, 2008), they may possess information and act on them, which consequently exert a pressure that induces volatility.

Emerging markets such as the Philippines require investor trust. Local investors expectedly provide this being the ultimate stakeholders as members themselves of that market. They are an organic member, and thus, their survival is naturally inseparable from its existence. This concern may not be shared by a foreign investor, because the latter does not directly operate in that market being an external player, thus he is not motivated by any reward except for the return incentive. Understandably, Perez (2015) laments the 39.1 billion peso sell-off by foreign investors of Philippine stocks, a concern that such herding or collective action may affect and influence the market negatively. Philippines at the time was not crisis; such reaction was simply a response to a market recovery overseas. Otherwise, it may have a lasting effect as was experienced in Indonesia where foreign investors displayed more herding than domestic investors (Bowe and Domuta, 2004). Certainly, it was far from crisis because while herding may come in the form of externalities such as liquidity and possible return on private information, it is not totally a rational act, which could have been propelled by other cues such as information cascades and pressure from others (Devenow and Welch, 1996). And yet, Perez (2015) remained composed about the market's resilience because of the expected support from the local investors, an optimism (Montealegre, 2016) that saw itself through months after, and regained back for the country some foreign funds.

But how much trust do external or foreign investors really have in Philippine market, more particularly, the Philippine stock market? From the discussion above, foreign buys approximate that trust, so that when trust is stable, it should be reflected in the level of foreign buys as reported daily on Philippine Stock Exchange, and when it is unstable, it is logical to expect an escalation in volatility. The following discussion should show how this can be measured.

As Benford's Law has been touted as a tool to detect fraud in the world of forensic audit (Durtschi et al., 2004), it may be applied to other data sets that do not violate the cardinal rule of compliance, that is, they should be naturally occurring numbers and free of intentional manipulation. Numerical figures that result from a combination of numbers are a likely candidate (Durtschi et al., 2004) and for any investor, it is common knowledge that net foreign buys of stocks share the same features. It is logical then to expect that this data set should conform to BL. Therefore,

H_0: The net foreign buys do not deviate from Benford's Law, signaling a stable foreign investors' trust.

H_a: The net foreign buys deviate from Benford's Law, signaling an unstable foreign investors' trust.

METHODOLOGY

Data

The data set (n= 2,405) comes from the daily report of net foreign buys of Philippine stocks proxied by PSEi, the main index of the Philippine stock market. It covers the period from April 3, 2006 to June 10, 2016, a modern PSE era that expects a more efficient trading and better transaction management.

Statistical Analysis

The data were analyzed through the first digit test of Benford's law employing the Ordinary Least Square (OLS) and Chi-squared test.

OLS Coefficients Test

The OLS equation of the form:

$$Y_i = B_0+B_1X_i+\varepsilon \quad (3)$$

Where:

Y = Observed proportion of digits i…n

X_i = Proportion of digits according to Benford's law

ε = Error term

tested the joint hypothesis $B_0=0$ and $B_1=1$. Perfect correlation or fit should return a zero value for the intercept coefficient and a value of 1 for coefficient of digit proportions (Saville, 2006). Software available online and downloadable for free from http://gretl.sourceforge.net/ called *GRETL* was used to produce the OLS results.

Chi squared Goodness of Fit

To check the conformance of the first digits, Chi-squared statistic was computed by:

$$\chi^2 = \sum_{i=1}^{9} \frac{(af-ef)^2}{ef} \quad (4)$$

Where, *af*= frequency of digit i; *ef* = expected frequency of digit i

RESULTS AND DISCUSSIONS

Figure 2 below shows the comparison of the distribution of observed data and BL distribution. It is apparent that the pattern of the observed data shows similar monotonic decline and close semblance to BL. Visual inspection however would be scrutinized by statistical tests in the next two sub-sections:

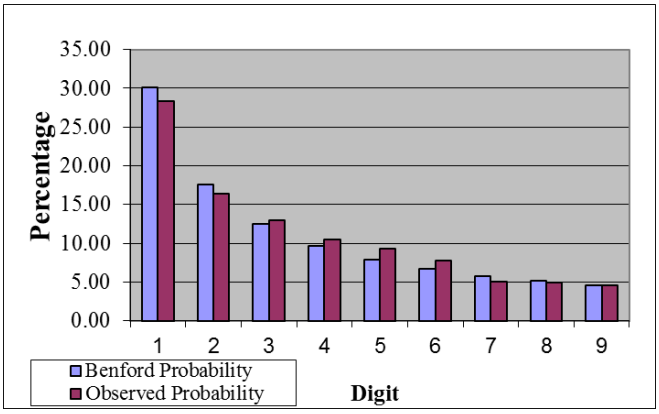

Figure 2: First Digit Test

OLS Results

The resulting estimate of equation (3) of the form $Y_i = B_0 + B_1X_i + \varepsilon$ are given below:

Yi = −.874206 + 1.07868Xi + ε

s.e. .588510 .0445204

To accept the joint hypothesis B_0=0 and B_1=1, it is necessary that the coefficients should be within 3 standard deviations from the assumed mean values of 0 and 1 for B_0 and B_1 respectively (Saville, 2006), because the acceptance region for alpha of 1% or confidence level of 99% covers the area under the standard normal curve, approximately 3 standard deviations to the left and right of the mean. Equivalently, setting B_0= 0, $Prob\left(-t_{0.005(n-2)} < \frac{\hat{B}_0 - 0}{s.e.} < t_{0.005(n-2)}\right)$ = 99%, or $\text{Prob}\left(\hat{B}_0 - t_{.005(n-2)}s.e.(\hat{B}_0) < B_0 < \hat{B}_0 + t_{.005(n-2)}s.e.(\hat{B}_0)\right)$ = 99%. Therefore, the confidence interval at 99% is: $\left(\hat{B}_0 - t_{.005(n-2)}s.e.(\hat{B}_0), \hat{B}_0 + t_{.005(n-2)}s.e.(\hat{B}_0)\right)$. Taking the values from the OLS results and the t-distribution table, the 99% confidence interval is (-2.93340, 1.18499).

In the same, manner, setting B_1= 1, $Prob\left(-t_{0.005(n-2)} < \frac{\hat{B}_1 - 1}{s.e.} < t_{0.005(n-2)}\right)$ = 99%, or $\text{Prob}\left(\hat{B}_1 - t_{.005(n-2)}s.e.(\hat{B}_1) < B_1 < \hat{B}_1 + t_{.005(n-2)}s.e.(\hat{B}_1)\right)$ = 99%. Therefore, the confidence interval at 99% is: $\left(\hat{B}_1 - t_{.005(n-2)}s.e.(\hat{B}_1), \hat{B}_1 + t_{.005(n-2)}s.e.(\hat{B}_1)\right)$, or (.0.92290, 1.23446) as computed. From the preceding, it follows clearly that the joint hypothesis is accepted at 99% level of confidence.

Chi-Squared

At n=2,405 the computed chi- square statistics, χ^2, is 19.627. At 99% confidence level, the critical level threshold for the chi-squared test with 8 degrees of freedom is 20. 0902, thus, the data set of PSEi net foreign buys conforms to BL at 99% confidence level.

CONCLUSIONS

This work intended to find out whether foreign investors have placed their trust and confidence in the Philippine stock market. By using 1BL, the standing null hypothesis was that the data set, in this case the net daily foreign buys, would not digress from Benford's Law. The result would form a basis to conclude that the volatility of foreign buys, which

translates to foreign trust and confidence, remain stable or balanced. Otherwise, if the volatility is not balanced and raised to an escalated level, it would imply an unstable foreign investor confidence. Based on chi-squared and joint OLS hypotheses tests, it can be concluded that the volatility of foreign buys of Philippine stocks is balanced, and therefore, the foreign investors' trust and confidence in this market is stable. It is recommended that other factors of investor confidence be explored and other methods employed for future studies on Philippine stocks. It would be interesting to find out the intensity of foreign buy's impact on stock price or return given the structural composition of the stock market.

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