Desirability Index with Sector Analysis for Investment Decisions by Bernoulli Theorem: A Case of FTSE-100

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Abstract: Due to complex and sophisticated nature of financial markets, many features including psychological, political and economic can influence the routine behaviour and considered by characteristic nonlinearities. There have been many efforts about the stock market prediction by using technical analysis methods. Concerning the application area of entropy into economics which could be referred as econophysics; there are two approaches that could be investigated within. These two could be named as ontological and metaphorical. As the Second Law of Thermodynamics has a critical role in the concept of ontological approach, the economy is considered as processes of physics and biology that are brought by energy while the metaphorical approach is more concerned with the application of finance and equilibrium theory on the info design of entropy. This research takes the metaphorical approach to the investigation of Oil & Gas Producers industry sector of the London Stock Exchange’s FTSE-100 index. First, we observed the necessity to analyse each stock with the Bernoulli Theorem to compute an index for the desirability of each to express the complexity of the investment decisions. Then, an analysis is conducted for the sector with the computation. During the computation phase, macroeconomic figures are introduced to the Bernoulli Theorem, as inflation. In addition to this, other stock movements in the sector are introduced for precise prediction as well as the parameter of the trading volume of each stock. With the suggested approach, the desirability index is formed as an unconventional theoretical approach within econophysics for expression of the complex nature of investment environment.

Keywords: Econophysics, Entropy, Thermodynamics Modelling, Bernoulli Theorem, Financial Markets, Stock Market

1. INTRODUCTION

The last two decades have witnessed extensive growth in econophysics including the implementation of econophysics courses for both physics and economics departments of the universities. Within the same period, the term econophysics is developed due to the connection of the previously mentioned two disciplines [1]. In his paper, Schinckus [2] approached in a neopositivist way to show the methodological differences between these two fields. Although his arguments reveal that the econophysics is refusing the conventional economics, the author places this new discipline as a contribution to the financial markets. The interrelation of these two was obvious even in the Wealth of the Nations where Sir Isaac Newton’s laws of motion are considered as a huge influence on Adam Smith during his efforts to determine the general laws of economics [3,4]. Among early and mid-19th century scientists, Belgian mathematician Adolphe Quetelet and French philosopher Auguste Comte predicted the idea that human conduct and economics could be ruled by physical laws and the latter lain the foundations of the term social physics [4]. These ideas are carried into the 20th century with the PhD dissertation The Theory of Speculation (Théorie de la spéculation) of Louis Jean-Baptiste Alphonse Bachelier on March 29, 1900. As a part of his dissertation, he brought the idea of the random walk for modelling the market prices [5]. Moreover, he defined Brownian motion five years earlier than Albert Einstein and formed a link between Brownian motion and the heat equation to theorize on financial options [6]. He also formed a foundation

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for Black and Scholes [7] in which they have conducted the first improvement for finding a solution for the option pricing problem since his 73 years earlier PhD dissertation.

The works of Louis Bachelier are considered fundamental for understanding the behaviour of financial series which leads to the efficient market hypothesis with the contributions of various scholars on the randomness of prices [8–10], is also one of the most discussed topics in economics [11–15]. Along with the efficient market hypothesis, particularly the works of Benoit Mandelbrot states that the corresponding distribution of series returns are a subject to a power law in which he studied Lévy-stable independent increments and multifractal model [16–18].

Vilfredo Pareto, an Italian economist, introduced a power law probability distribution to observe many different phenomena including wealth. It is linked to the concept of scale invariance that is broadly utilized in economics, especially in finance with modelling of volatility, Brownian motion and analysis of fluctuations. This absence of any distinguishing measure is a curious subject to study at first glimpse. However, complex systems theory holds its fundamental basis on the matter.

Human-driven systems and events in nature are not often differing since they are not remote actions. Their distribution labels them due to its share of entire probabilistic events. Nature is driven by a wide range of actions differing from flooding to a sunny winter day. Consequently, it appears to be a practical approach to observe this phenomenon in financial markets. In other words, they can be explained as the rivers and in the long run, we can expect to flood due to a heavy rain; the power law of Vilfredo Pareto states that the amount of flooding is distributed by itself and is expected to occur significantly with a lower probability as the rainfall increases as in equation 1.

\[
P(X > x) \sim x^{-\alpha}
\]

Classification of oscillations in the economy is foremost anxiety that physics is addressed [19,20] by agent-based models [21,22]. Notwithstanding the advances completed by those representations, there are several issues to be considered. In agent-based models, rule-designing cannot be considered as an easy task and similar conventional evidence can be led by dissimilar sets of rules. This brings the question of assessing and testing these rules. Particularly, at times these rules change through time as automated traders with altering strategies are becoming more popular.

A probable critical state of financial markets should be considered as another significant question for econophysicists. Soon, likenesses between physical systems that are at the critical level and conventional facts are signalling to occur more frequently, specifically in data integration, power law, clustering etc.

Although the term econophysics -in other words, the integration of economics with statistical physics- is emerged during the conference in Kolkata in 1995, still a new phenomenon. Over the years, econophysicists are using the philosophies from the fields of quantum mechanics and other areas of physics to investigate the financial laws for offering a solid background in return [23]. Due to its groundwork, econophysics is trying to explain the financial instabilities using power laws. However, economists show little interest in the field as most of the assumptions in the economy are constructed based on the impossibility of normal distribution and large deviations [1]. Regardless of the prior discussion, the late 90s and 00s seen tremendous contributions to the field with a growing interest ranging from DNA and physiology to cities and administration [19,24–29]. Previously mentioned structures were investigated in [19,30,31] from the economics point of view while [32] for physics and multifractal stochastic processes as in [33]. Yet, the declaration of the mentioned critical point is phenomenal [34,35].

Moreover, Schneidman et al. [36] indicate that multiple information principles have the ability to gather statistical dependencies. Similarly, authors permit an assessment of present activities as noise-dressed correlation matrix [37] or as stated in Mantegna [38] and Onnela et al. [39] structural reorganization. The remaining outcomes of the critical phase can similarly be compared to the severe empirical assessments that are revealed from the statistical physics [40]. Furthermore, shared dynamic forces of the market can be emphasised with the implementation of a model that is undoubtedly indicating a period of greater inter-covariance. Quantitative and qualitative forecasting approaches are summed to more 300 models as of today. Expert system, Delphi, trend prediction are the most notable for qualitative prediction while regression analysis, time series, artificial neural networks, genetic algorithm and many other for quantitative estimations [41]. Among all, one of the most noteworthy works is introduced by Deng [42] with Grey theory which addresses the lack of information operational mechanism. This
method is applied widely in many research areas, such as; energy performance, transportation and agriculture [43–45]. Bernoulli, however, is introduced to nonlinear grey model for estimating unemployment rate by Chen [46], to the foreign exchange rates in the article of Chen et al. [47] and to stock indices of Taiwan by Chen et al. [48]. Econophysics has underlined in one of the key branches of physics namely entropy. This concept is also considered central to statistical mechanics. Ontologically, it is positioned in econophysics via Second Law of Thermodynamics by way of a powerful strength in driving the economy of the world [49]. Within the concept, the economy is considered as processes of physics and biology that are brought by energy. However, it should not be measured as a big surprise to observe that these two concepts investigated by mutual probability distributions of logarithms of products for system’s likely conditions or the world itself in the end. On the contrary, the metaphorical approach is more concerned with the dynamics of finance and equilibrium theory on the info design of entropy. Over the years, scholars tried to explain the role of the entropy in economic theory or more generally, physics’ role in economics [23,50–54].

The ontological approach to entropy is not only derived from the direct effect of energy but also a foundational role in the complex systems. It is not always necessary to limit the use of energy for manufacturing, electricity provision or transportation as it could be further used to elaborate the global complex theories and systems. As it was explained in detail within the works of Georgescu-Roegen [55] and Daly [56], it is not a big surprise to focus on its brought up subject thermodynamics as the earth’s system will allow the Law of Entropy as long as the solar energy exists. However, it should not solely be observed within the scope of the solar energy but also reflects the economic activity with ecosystem depending on the previously mentioned energy. Georgescu-Roegen [55] further discussed the argument as it could potentially be extended to the economy. On the other hand, commencing with the works conducted circa the 80s proposed criticisms to the theory especially with the arguments of solar magnitude is falling short to explain economy [57–60].

Furthermore, to extend the relationship among entropy, physics, economy and other social concepts; studies are conducted with stochastic and Markov process dynamics in social policies that are developed in the form of migration pattern recognition and models with many other [61–63]. In addition to this, the concept of entropy is also fundamental in biophysics. In this field, Martin et al. [64] investigated thermodynamic calculations explain the heat influence on bacteria. The work states that entropy will considerably drop due to the small hydrogen and carbon dioxide materials conversion to macromolecules. Caetano-Anollés et al. [65] also introduced the entropy concept to archaea with the discussion Shannon entropy probability matrix as well as Eddington’s entropy-induced asymmetry.

Entropy is extensively used in stock market estimations. Among recent works, Dow Jones Industrial Average (DJIA), The Nasdaq Stock Market is an American stock exchange (NASDAQ), and The Standard & Poor’s 500 (S&P 500) indexes of the U.S. stock market investigated from the econophysics perspective particularly based on singular value decomposition, trajectory matrix, DCCA cross-correlation analysis, diffusion entropy and Shannon entropy [66–71]. Others are conducted to Taiwan Stock Market (TWSE), Stock Exchange of Thailand (SET), Shenzhen Component Index and Chilean Stock Market based on the artificial stock market, maximum entropy bootstrap, information theory, and singular value decomposition respectively [72–75]. Among all the works studied, entropy is commonly positioned as increasing phenomena in a closed thermodynamic system. Dionisio et al. [76] summarized the role of entropy in financial theory as an increasingly adapted measure of diversification, uncertainty, dispersion and disorder. The paper continues with methodology, analysis and findings and the conclusion.

2. METHODOLOGY

Fluid materials can take the shape of the container they are in. Shear and tangential forces of equilibrium cannot be withstood by fluids. To some extent, all of them own the ability of compressibility while reflecting tiny amounts of resistance for shaping alteration. Fluid mechanics is a phenomenon that investigates the stagnant or moving behaviour of the fluids. In the development of fluid mechanics principles, many of its features have been important roles. Fluid dynamics, however, is a phenomenon that studies the change of substances under a variety of forces in mechanical physics.
In fluid dynamics, Bernoulli's principle denotes that as the velocity increases either the potential energy or the pressure decreases for non-frictional fluids. This principle is named after Swiss mathematician Daniel Bernoulli after his 1738 work of Hyrodynamica. This principle can be extracted from the law of conservation of energy. According to this, the sum of all mechanical energies of a fluid that is moving in a road within a constant stream is equal to every point of the same road. This expression declares that the summation of the kinetic and potential energies is a constant. Thus, any rise in the velocity of the fluid reduces the potential energy, grows the dynamic pressure and the kinetic energy proportionally and diminishes the static pressure as well. Another way to obtain the Bernoulli theorem is the Second Law of Newton. If fluid having a small-volume streams level from the high-pressure area towards the low-pressure area indicates that additional pressure exists at the rear compared to the front. It is assumed that the fluid does not have viscosity and heat conduction when applied to fluids. This provides an acceleration along the streamline by applying a net force on the fluid.

The one-dimensional Euler reckoning can be straightforwardly combined with any points due to the constants of \( \gamma \) and \( g \) to acquire

\[
\frac{p_1}{\gamma} + \frac{V_1^2}{2g} + z_1 = \frac{p_2}{\gamma} + \frac{V_2^2}{2g} + z_2 \tag{2}
\]

Considering both points are arbitrarily chosen, the measure

\[
\frac{p}{\gamma} + \frac{V^2}{2g} + z = H = \text{Constant} \tag{3}
\]

applies to every arbitrary point. Therefore, offers a valuable connection between the magnitude \( V \) of the velocity, the height \( z \) and pressure \( p \) as discussed in the previous equation. Equation (3) is recognised as the Bernoulli equation where Bernoulli constant is denoted by \( H \) (generally referred as total head) - in our case, the desirability index for a given stock in a financial market. The terms of the third equation disclose that \( p/\gamma \) and \( z \) can be pictured as perpendicular distances while reflecting the pressure (either gage or absolute) and potential heads/index respectively. Total speed head \( V^2/2g \) and pressure \( p/\gamma \), potentially be measured by employing a small-scale open pipe in the stream with its open-end upstream. Therefore, given the continual distance between the flat plane and the entire line of energy could be yield variable pressure in the flow. Consequently, a straight measure of the static pressure could be derived from the distance from the tube and the remoteness from the line of energy is proportionate to the square of the velocity.

Moreover, in a steadily flowing stream-due to its pressure- a fluid owns the ability to do the work as well. In an arbitrarily chosen cross-section, the pressure creates a force and -due to the flowing fluid-the cross-section would shift frontward to do the work and this work done per unit weight is indicated as \( p/\gamma \). Since this term is identified as the pressure energy-due to its flow under pressure-, this study considered the term "p" as the behaviour of the same group of stocks such as Oil & Gas Producers of FTSE-100 and \( \gamma \) denotes the division of adjusted close value to the volume of transactions conducted in an arbitrarily chosen day. Pressure energy perception is rather tough to comprehend in many cases. There is no restriction for a body to alter its velocity in solid body mechanics. Therefore, as its level reduces, it is also able to transform its potential energy into kinetic due to the height of the term \( z \)-which is considered as the mean of the stock in annual terms given that determining an estimated level for it. However, the rate of the velocity is conditional to the cross-sectional area. We should not expect a change in velocity if the tube is uniform. Hence, increased pressure is expected to be observed as an energy surplus. Consequently, it is fair to consider the potential energy of the transfer as the pressure energy. However, it should not be expected in financial stock markets due to socio-political and macroeconomic externalities. Therefore, the velocity is not expected to be constant. Given the reason, velocity is considered as a value change of the stock which is derived by the adjusted close values of the investigated time horizon, where the gravity is reflecting as \( [1 - (1/inflation)] \). In this study, gravity is relational to the inflation for aiming to present a special large influence and an outer effect that the dynamics of the macroeconomic balances reflect. The reason for its placement in the denominator and its deduction from 1 is to define a negative interest in the stock when inflation increases. To sum up,
pressure energy \([p/\gamma]\), kinetic energy \([V^2/2g]\), and the potential energy \([z]\) are the three terms of Bernoulli equation where their sum yields the desirability measure of the stock.

3. ANALYSIS AND FINDINGS

In a typical portfolio analysis, it is expected to see a variety of companies from a wide range of industries. The background motivation is to reduce correlation via generating a diversification strategy. The stage of correlation is crucial for risk reduction. This aids the basket of stocks by eliminating industry-specific problems. Any potential negative trend in an industry -which assumed to be the only sector that the portfolio has- entire portfolio shares the risk which may end up with a loss. However, this study aims to investigate the behaviour of each stock within their industry sector. This is also introduced to observe their performance within the imaginary tube of the same type of stocks -in other words, the correlation and the systemic risk is also considered.

Oil & Gas Producers industry sector is selected in the Financial Times Stock Exchange 100 Index (FTSE-100) of London Stock Exchange. The sector consists of two different companies with three indexes which are; BP PLC, Royal Dutch Shell PLC 'A', Royal Dutch Shell PLC 'B' with market capitalizations of 96.96, 105.54 and 89.33 billion GBP respectively as of Dec 8th, 2017.

![Figure 1](https://example.com/figure1.png)

**Figure 1.** Historical Performance of Oil & Gas Producers of FTSE-100: (a) BP, (b) Royal Dutch Shell ‘A’, (c) Royal Dutch Shell ‘B’ (londonstockexchange.com)

Historical performance of Oil & Gas Producers of FTSE-100 index is introduced in figure 1. Their performances are indicated in percent change in the vertical axis while the horizontal axis is reflecting the time, in this case, time horizon has a year-length. The darker lines in all three graphs are the performance of the stock while lighter reflects the overall performance of FTSE-100. As it could be inferred from the graphs, oil & gas producers’ industry sector did not perform better than the index. Three graphs indicate that at the end of 2016 and at the early days of 2017 companies were performing better than the index and the followed low trend is turned towards positive moves again at the end of 2017. However, BP is still performing worse than the other two.

Previously mentioned three phases are introduced during the Bernoulli implementation. In the kinetic energy phase \([V^2/2g]\) the square of velocity is defined as in equation 4.
\[ V_0^2 = \left[ \frac{\text{Adj. Close}_0}{\text{Adj. Close}_{-1}} \right]^2 \]  

(4)

The inflation rate for the United Kingdom is considered during the calculations. Data is obtained from the inflation.eu website for the change during the corresponding month. At times when there is no change in inflation compared to the previous month, a negligible rate close to zero is considered. However, the inflation rate is not directly imported into the equation as a negative change in inflation would decrease the desirability level of the stock. Given the reason, the gravity is implemented as in equation 5.

\[ \text{inf} = 1 - \frac{1}{g} \Rightarrow g = \frac{1}{1 - \text{inf}} \]  

(5)

For the pressure energy phase \([p/\gamma]\), the value of \(p\) owns a crucial role in the system. It has the role to integrate the behaviour of the same group of stocks in the system - by offering the same group, same industry sector is mentioned. Therefore, the value of \(p\) is taken as the sum of all the trading volume in the given industry sector - in our case, Oil & Gas Producers. Since the size of trades is extremely high in FTSE-100, normalization is applied by \(10^7\) to converge it to smaller figures. Similarly, \(\gamma\) is extended by \(10^3\). The role of \(\gamma\) is determined by the division of the adjusted close to the trading volume. Since this division is the denominator of the main formula, any increase in volume would affect positively to the desirability index, in other words, the stock would become attractive. Correspondingly, increasing adjusted close value is a repelling force for the investors hence, it reduces the desirability. Therefore, the overall formula is formed as in equation 6.

\[ C_1 = z + \frac{p_0}{\gamma_0} + \frac{V_0^2}{g_m} \]  

(6)

Where \(C_1\) reflects the desirability index for the next period (any time horizon for the estimations) and the subscript \(m\) refers to the investigated month for the Bernoulli estimation. Thus, the equation is expanded to an open form as in equation 7.

\[ C_1 = z + \sum Volume_0 \frac{\text{Adj. Close}_0}{\text{Adj. Close}_{-1}} \left[ \frac{\text{Adj. Close}_0}{\text{Adj. Close}_{-1}} \right]^2 \]  

(7)

Where \(\sum Volume_0\) states the total volume of the industry for the investigated day. Given the equation, the desirability indexes are calculated for all FTSE-100 Oil & Gas Producers sector as in figure 2.

Figure 2. The Desirability Index

Figure 2 indicates that RDSA and RDSB stocks are performing better than the BP because of the Bernoulli implementation to the industry sector. Compared to figure 1, where historical performances are observed for each of this stock, the desirability index of figure 2 reflects the similar behaviour of the
stock. Therefore, the desirability index -derived from the Bernoulli theorem- could be investigated further for alternative investment method for investors.

4. CONCLUSION

This study investigated the contribution of physics to the economics from the works of Isaac Newton, Adam Smith, mathematician Adolphe Quetelet and philosopher Auguste Comte in the form of econophysics. Evidently, the literature is heavily based on the PhD thesis (Théorie de la spéculation) of Louis Bachelier in which he studied random walk in Sorbonne, Paris. Furthermore, grounds of efficient market hypothesis and power law, which is particularly contributed by Mandelbrot with the influence of Pareto, studied extensively in this article. Along with the need of clear definition in the complex systems and the power of entropy to do so, the term econophysics is evolved in the last twenty years. Although this concept has first appeared in finance, different areas that import econophysics are discussed in this article from biology and physiology to the city administration.

This study expanded this research area further by focusing on the Bernoulli theorem for preparing an index that shows the desirability of the stock for an investor. Although the development of this index is still in its early days, preliminary results are promising. However, the theorem should be tested for all the industry sectors with more historical data points to make a solid contribution to the literature. The index should not also be limited to FTSE-100. Hence, the potential of the desirability index could be strengthened by focusing on different stock markets from different continents where investment behaviour and attitude towards the stock price may differ.

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