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Duality in Finance

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Abstract

From the implication of the book of Way, or the book of Daodejing by Laozi, what appears to be misfortune may pave the way for fortune? What appears to be fortune may pave the way for misfortune? The quantum entanglement between the fortune and misfortune can be described by Yin-Yang Taiji. Profit and risk existed in the financial market as a duality. Duality denotes the relationship and entanglement between the profit and risk in the financial market.

Keywords: *Duality, Finance, Quantum Entanglement, Chinese Taiji, Yin-Yang, Profit, Risk.*

1. Introduction

Chinese Laozi said Way or Dao that can be spelled out.[1] Cannot be the eternal way. Names that can be named. Must change with time and place. “Emptiness” is what I call the origin of heaven and earth. “Existence” is what I call the mother of everything that had a birth.

The book of EA or Changes said, in the system of EA there is the Great Ultimate, it generates the two Modes (Yin and Yang).[2] The two Modes generate the four Forms. The four Forms generate the eight Trigrams. The eight Trigrams generate the sixty-four divinatory trigrams or phenomena. The Chinese Taiji generates everything through duality.

The micro observation of the world from the view of the Chinese Taiji matched with the Quantum mechanics’ duality. The quantum entanglement can be described by Yin-Yang Taiji, and the quantum superposition can be described by eight Trigrams. The Nano science application can be enriched by Quantum mechanics and Taiji philosophy likes quantum computer, quantum telegraph, and quantum medicine. Appreciate emptiness from Taiji, that we may see nature of the Way’s versatility. Appreciate existence, that we may see the extent of the Way’s possibilities.

Yin-Yang entanglement in Taiji describes the duality in the universe. The thought of Yin-Yang of Taiji used by Laozi’s Daodejing. For example, chapter 58 of Daodejing denotes good life under a non-interventionist government. What appears to be misfortune may pave the way for fortune. What appears to be fortune may pave the way for misfortune. And what is good may prove to be bad. What is the fortune? And what is the misfortune? The quantum entanglement between the fortune and misfortune can be described by duality of Yin-Yang Taiji.

In financial market, profit is the fortune, risk is the misfortune, and risk denotes loss generally for investors. What is duality in financial markets? Profit and risk existed simultaneously in the financial market. Ying is the opposite of Yang. Similarly, profit is opposite of loss, or risk for sure. As to the profit and risk in financial market, both of them tie together, or co-existence with a positive relation rather than opposite to each other. This paper discusses duality in three main finance theory below.

2. Capital asset pricing model (CAPM)

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[1] Daodejing wrote by Laozi, is a classical philosophy book. Daode means morality or ethics, it also denotes the way of associated with God and human being separately. Dao in Chinese means way. The essence and marrow of Daodejing came from the book of EA.

[2] The book of EA or Changes wrote by an emperor also the founder of Chao dynasty in eleven century B.C. The book of EA or Changes was fountainhead or source of all Chinese philosophy. EA in Chinese means changes.

The CAPM was introduced by Jack Treynor (1961, 1962), William F. Sharpe (1964), John Lintner (1965) and Jan Mossin (1966) independently, building on the earlier work of Harry Markowitz (1952) on diversification and modern portfolio theory which is the origin of investment.

The CAPM is a model for pricing an individual security or portfolio. For individual securities, we make use of the security market line (SML) and its relation to expected return and systematic risk (beta) to show how the market must price individual securities in relation to their security risk class.

The SML enables us to calculate the profit-to-risk ratio for any security in relation to that of the overall market. The market profit-to-risk ratio is effectively the market risk premium.

The market reward-to-risk ratio is effectively the market risk premium and by rearranging the above equation and solving for E(Ri), we obtain the capital asset pricing model (CAPM). From the implication of equation (1), there is a entanglement between the expected return of an asset and its systematic risk β.

$$E(R_i) = R_f + \beta_i \cdot (E(R_m) - R_f) \tag{1}$$

Restated, in terms of risk premium, we find that:

$E\ (R_i)$ - $R_f = \beta_i\ (E(R_m)$ - $R_f)$ where:

$E(R_i)$ is the expected return on the capital asset.

R_f is the risk-free rate of interest such as interest arising from government bonds.

β_i (the beta) is the sensitivity of the expected excess asset returns to the expected excess market returns, or also

$$\beta_i = \frac{Cov(R_i, R_m)}{Var(R_m)} = \rho i_1 m \frac{\sigma_i}{\sigma_m} \tag{2}$$

$E(R_m)$ is the expected return on the capital asset.

$E(R_m)$-R_f is sometimes known as the market premium (the difference between the expected market rate of return and risk-free rate of return).

$E(R_i)$-R_f is also known as the risk premium.

$\rho i_1 m$ denotes the correlation coefficient between the investment *i* and the market *m*.

σ_i is the standard deviation for the investment *i*.

σ_m is the standard deviation for the market *m*.

3. Generalized Autoregressive conditional heteroskedasticity (GARCH)

In econometrics, the autoregressive conditional heteroskedasticity (ARCH) model is a statistical model for time series data that describes the variance of the current error term or innovation as a function of the actual sizes of the previous time periods' error terms, often the variance is related to the squares of the previous innovations.

The ARCH model is appropriate when the error variance in a time series follows an autoregressive (AR) model; if an autoregressive moving average (ARMA) model is assumed for the error variance, the model is a generalized autoregressive conditional heteroskedasticity (GARCH) model

To model a time series using an ARCH process, let ϵt denote the error terms (return residuals, with respect to a mean process), i.e. the series terms. These ϵt are split into a stochastic piece z_t and a time-dependent standard deviation σ_t the typical size of the terms so that

$$\epsilon_t = \sigma_t z_t \tag{3}$$

The random variable z_t is a strong white noise process. The series σ_t^2 is modeled by

$$\sigma_t^2 = \alpha_0 + \alpha_1\epsilon_{t-1}^2 + \cdots + \alpha_q\epsilon_{t-q}^2 = \alpha_0 + \sum_{i=1}^{q}\alpha_i\epsilon_{t-i}^2 \tag{4}$$

where $\alpha_0 > 0$ and $\alpha_i \geq 0, i > 0$.

An ARCH(*q*) model can be estimated using ordinary least squares. A methodology to test for the lag length of ARCH errors using the Lagrange multiplier test was proposed by Engle (1982). This procedure is as follows:

Estimate the best fitting autoregressive model AR(q) $y_t = a_0 + a_1y_{t-1} + \cdots + a_qy_{t-q} + \epsilon_i = a_0 + \sum_{i=1}^{q} a_i\, y_{t-i} + \epsilon_t$.

Obtain the squares of the error $\hat{\epsilon}^2$ and regress them on a constant and q lagged values:

$$\hat{\epsilon}_t^2 = \hat{\alpha}_0 + \sum_{i=1}^{q}\hat{\alpha}_i\hat{\epsilon}_{t-1}^2 \tag{5}$$

where q is the length of ARCH lags.

The null hypothesis is that, in the absence of ARCH components, we have $\alpha_i = 0$ for all $i = 1,\ldots,q$. The altermative hypothesis is that, in the presence of ARCH components, at least one of the estimated α_i coefficients must be significant. In a sample of T residuals under the null hypothesis of no ARCH components, the test statistic T'R2 is greater follows x^2 distribution with q degress of freedom, where T'is the number of equations in the model which fits the residuals vs the lags (i.e.T'= T-q). If T'R2 is greater than the Chi-square table value, we reject the null hypothesis and conclude there is an ARCH effect in the ARMA model. If T'R2 is smaller than the Chi-square table value, we do not reject the null hypothesis.

From the implication of equation (5), generalized autoregressive conditional heteroskedasticity (GARCH) model, there is a entanglement between a stochastic piece zt and a time-dependent standard deviation σt.

4. Black–Scholes Model

The Black–Scholes or Black–Scholes–Merton model is a mathematical model for the dynamics of a financial market containing derivative investment instruments. (Black and Scholes, 1973) From the partial differential equation in the model, known as the Black–Scholes equation, one can deduce the Black–Scholes formula, which gives a theoretical estimate of the price of European-style options and shows that the option has a unique price regardless of the risk of the security and its expected return (instead replacing the security's expected return with the risk-neutral rate).

The Black–Scholes formula calculates the price of European put and call options. This price is consistent with the Black–Scholes equation as above; this follows since the formula can be obtained by solving the equation for the corresponding terminal and boundary conditions.

The value of a call option for a non-dividend-paying underlying stock in terms of the Black–Scholes parameters is:

$$C(S_t, t) = N(d_1)S_t - N(d_2)PV(K) \tag{6}$$

where,

$$d_1 = \frac{1}{\sigma\sqrt{T-t}}\left[1r\left(\frac{s_t}{K}\right) + \left(\gamma + \frac{\sigma^2}{2}\right)(T-t)\right]$$

$$d_2 = d_1 - \sigma\sqrt{T-t}$$

$$PV(K)=K_e^{-r(T-t)}$$

The price of a corresponding put option based on put-call parity is:

$$P(S_t, t)= K_e^{-r(T-t)} - S_t + C(S_t, t) = N(-d_2)Ke^{-r(T-t)} - N(-d_1)S_t \tag{7}$$

For both, as above:

N(・) is the cumulative distribution function of the standard normal distribution.

$T - t$ is the time to maturity (expressed in years).

S_t is the spot price of the underlying asset.

K is the strike price.

$\boldsymbol{\gamma}$ is the risk free rate (annual rate, expressed in term of continuous compounding).

$\boldsymbol{\sigma}$ is the volatility of returns of the underlying asset.

From the implication of equation (6) and (7), the Black-Scholes option model, there is an entanglement between the risk of the security and its expected return in a unique options' price.

5. Conclusion

The book of Way, or the book of Daodejing by Laozi say, ways that can be spelled out, and cannot be the eternal way. Names that can be named, and must change with time and place. "Emptiness" is what I call the origin of heaven and earth; but also denotes the entanglement between the risk of the security and its expected return in financial market. What is the reality about the relationship between the risk of the security and its expected return in financial market? Duality can be explained easily. Duality denotes the relationship and entanglement between the profit and risk.

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