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A Hyper-inflation Hybrid MultiRisk Asset Pricing(HHMRAP)Framework for Zimbabwe'sListed Stocks

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Abstract

Theresearchexamined the behaviour of some of theasset pricing models under unstable economic conditions at the Zimbabwe Stock Exchange(ZSE). The researchassessed how the asset investment sector in Zimbabwe was copying with the new asset pricing models such as the Black-Scholes theory.The Supply and Demand (S&D)theory was found to beunreliable in unstableand unpredictable economic conditionsbecauseit was under-estimating the value ofthe listed stocks. The researchdeveloped an asset pricing frameworkand namedit the Hyper-inflationHybrid Multi-Risk Asset Pricing (HHMRAP) framework. The HHMRAP frameworkcould be used as an alternative asset pricing tool of listed stocksat the ZSE. The HHMRAP framework was tested in hyper-inflation environment andproduced satisfactory results.

Keywords: Hybrid Multi-Risk Asset Pricing Model, Hyper-inflation, Stock Exchange, Demand and Supply theory, Black-Scholes theory
JEL:E44, G11
Paper Classification: Research Paper

Introduction

The researchinvestigated some of the asset pricing and risk management techniques that are used to price and interpret asset market data at the Zimbabwe Stock Exchange (ZSE). Theinvestment managers and individuals have difficult task of choosing reliable asset pricing models which have sustainable and manageable risk levels underunstable and unpredictable economic conditions. The variousfactors that are considered for managing portfolios make the selection of the asset pricing modelmore complex. The asset pricing professionals face a dilemma onwhether or not to abandon the past success conceptual approach to more mathematical approach that are based on utility theory, mean and variance analysis, stochastic calculus and similar methodologies. The results obtained byMurairwa (2007)indicatethat the ZSEasset pricingframework wasunder-estimatingor over-estimating the value of the listed stocks in unstable economic conditions.

The Dow-Jones IndustrialAverage(DJIA) is probably the most quoted index and itwas developed in 1986 by Dow Jones. The Standard and Poor's Composition 500 (S&P 500),which measures the market performance, resembles a portfolio made up of 500 common stocks that are randomly selected as follows: 400 industrial, 40 public utility, 20 transportation and 40 financial stocks.The Industrial and Mining indicesare used at the ZSE. The Industrial index had 67 registered companies while the Mining index had 8 registeredcompanies.The Industrial and Mining indices measure the performance of industrial and mining companies respectively.These are used to determine the stock prices at the ZSE. The other commonly used indices are the New York Stock ExchangeComposite which is calculated along the same lines as the S&P500 but it uses all stocks instead,the Tokyo Topix Exchange which is a value weighted index of the first 150 stocks, the Nasdaq Composite is composed of all over-the-company stocks and it is determined in the similar manner as the S&P500 andthe Morgen Stanley Capital International (MSCI) world index. When it was established, the MSCI had 16 registered national capital markets which have now increased to 51 countries excluding Zimbabwe. The indices were calculated using the Laspeyres' concept of a weighting arithmetic average together with the concept of chain linking.

Since Markowitz's(1952)pioneering work, a great stride has been made in furthering research and implementing the asset pricing models.The researchers such as Lee (2004),Black and Scholes (1973) and Sharpe (1964),have contributed tremendously to the adaptation and implementation of the asset pricing models.The industrial and mining companiesthat are considered in this research were listed on the ZSE, a bourse that was started in 1946. Despite that it was rated the second best performer in the world's emerging capital markets with more than 75 listed companies(Murairwa, 2007), the economic recession coupled with hyper-inflation, unemployment and withdrawal by investors threatened its existence. That rendered some of the asset pricing models redundant and thus, the situation called for an urgent review of the ZSE's asset pricing model.The Supply and Demand theorywas foundin Murairwa (2007)to be unreliableinunstable and unpredictable economic conditions.This research examinedthe applicability of the asset pricing and risk management modelsat the ZSE in unstable economic conditions.

Literature review

A beta (β) is a measure of an asset's non-diversifiable or systematic risk(Subing, Kusumah, & Gusni, 2017). It can also be defined as a constant that measures the expected change in the rate of return on stock given the rate of return on the market index. This is a gauge of the sensitivity of a security to movements in the market. The Capital Market theory demonstrates that the systematic risk is what should be rewarded and empirical results show that higher risk assets have, in fact, earned higher returns over longer periods than lower risk assets. The beta parameters are sensitivity coefficients with respect to the indices. The higher beta values indicate greater sensitivitywhereas the lower beta values indicate lesser sensitivity of the stock price to a particular index. This is a key element in selecting an individual asset for inclusion in a portfolio (Farrel, 1997).

A risk describes any situation where there is uncertainty about what outcome will occur. In 2006, Nictiaus described it as variability around the expected value or losses. The risk can be avoided, transferred and averse in an attempt to reduce its impact. There are two major types of risks, namely,the Systematic and Non-systematic risks. The total risk is the addition of the Systematic risk and Non-systematic risk. The Non-systematic risk is attributable to factors that are unique to an asset. An investor can construct a diversified portfolio and eliminate part of the total risk, that is, the Non-systematic risk.What will remain is the Systematic risk. This risk cannot be avoided and therefore, it is critical to all investors. The Systematic risk is attributable to broad macro factors affecting all assets. The variability in an asset's valuation that is not related to overall market variability is called the Non-systematic (Non-market) risk. It is unique to a particular asset and it is associated with such factors as business and financial risk as well as liquidity risk.

Single Index Model

Security prices may be correlated because of their common response to the market. A casual look shows that when the industrial index falls (rises), the stock prices falls (rises) as well. So instead of direct comparison of correlation between assets, the researcher can look at each asset's correlation with the market. A very common simple model that depicts this relationship is$R_i = \alpha_i + \beta_i R_m$, where R_i is the rate of return on stock i, $\alpha_i = \gamma_i + \varepsilon_i$ is the component of asset i's rate of return that is independent of the market's performance, a random variable, R_m is the rate of return on the market indexand β_i is a constant that measures the expected change in R_i given a change in R_m. Therefore,the beta$i(\beta_i)$value is computed with$\beta_i = \frac{Cov(R_i, R_m)}{Var(R_m)}$.Given that $\sigma_{e_i}$and σ_m are the standard deviations of $\varepsilon_i$and R_m respectively, the assumptions of the model are$E(\varepsilon_i) = 0$, $Var(\varepsilon_i) = \sigma_i^2$, $E(\varepsilon_i, \varepsilon_i) = 0$, $(i \neq j)$, $i,j = 1, 2, \ldots, N$, $E(\varepsilon_i, R_m) - E(R_m) = 0$, $i = 1, 2, \ldots, N$ and $Var(R_m) = E\big(R_m - E(R_m)\big)^2 = \sigma_m^2$.Therefore, the expected price,variance (risk) and covariance expressions for the Single Index model are$E(R_i) = E(\alpha_i + \beta_i R_m) = \gamma_i + \beta_i E(R_m)$,$Var(R_i) = Var(\alpha_i + \beta_i R_m) = \sigma_{e_i}^2 + \beta_i^2 \sigma_{R_m}^2$and $Cov(R_i, R_j) = Cov(\alpha_i + \beta_i R_m, \alpha_j + \beta_j R_m) = \beta_i \beta_j \sigma^2 R_m$(for $i \neq j$)respectively.

A look at the model shows that the researcher needs a total estimate of$3N + 1$in order to be able to perform portfolio analysis. This is much less than the $2N + \frac{N(N+1)}{2}$estimate required when the correlation between assets isestimated directly. Thus, the Single Index model reduces the amount of data required in order to be able to perform portfolio analysis. The Single Index modeluses historical data to estimate the risk factor (beta). This makes the model easy and simple to implement. This is the only asset pricing model which provides a formula for selecting the counters to be included into the portfolio. The counters with the highest betas are included into the portfolio while those with the smallest betas excluded.The systematic risk measured by $\hat{\beta}_i = \frac{\sigma_{im}}{\sigma_m^2} = \frac{\sum_{t=1}^{N}[(R_{it} - E(R_{it}))(R_{mt} - e(R_{mt}))]}{\sum_{t=1}^{N}[R_{mt} - E(R_{mt})]^2}$(Jogiyanto, 2013)and $\hat{\gamma}_i = \bar{R}_i + \hat{\beta}_i \bar{R}_m$is not perfectly stationary over time because it is affected by changes in companies such as capital structure changes. Therefore, this makes the calculation of the individual systematic risk difficult when using the model. The model uses historical data for predicting asset prices and risk. This may sound to be an advantage but the estimated values will be under or over estimating the current asset prices completely dismissing the purpose of using the model. If there are sudden changes in the economy which directly affect asset prices, the model cannot detect it and this may negatively or positively affect the whole asset pricing system. The model does not take into consideration all the factors that affect pricing of assets such as unemployment and inflation among others, since it uses current asset prices and market index price (Farrel, 1997). The model assumes that the systematic risk is not random. This can only be true if the economy is stable. A stable economy is difficult to achieve and therefore the model is a theoretical model which cannot be used to explain any market asset prices.

Suppose β_p is a weighted average of the individual $\beta_i s$ on each stock in the portfolio where the weights are the fractions of the portfolio invested in each stock, then$\beta_p = \sum_{i=1}^{N} p_i\beta_i$and if$\gamma_p$is defined in a similar fashion, then$\gamma_p = \sum_{i=1}^{N} p_i\gamma_i$. Therefore, using the SingleIndex model's expected formula$E(R_i) = \gamma_i + \beta_i E(R_m)$ and $E\left(R_p\right) = \sum_{i=1}^{N} p_i E(p_i)$, theformulafor computing any portfolio's expected returnis$E\left(R_p\right) = \sum_{i=1}^{N} p_i\left(\gamma_i + \beta_i E(R_m)\right) = \sum_{i=1}^{N} p_i\gamma_i + \sum_{i=1}^{N} p_i\beta_i E(R_m) = \gamma_p + \beta_p E(R_m)$.

If a portfolio $P$is selected, where $p_1 = p_2 = \ldots = p_N$,then the expected value of the portfolio is given by$E\left(R_p\right) = E(R_m)$if $\gamma_p = 0$ and$\beta_p = 1$. This means that β on the market is 1 and thus an asset is more or less risky than the market according to whether its beta is larger or smaller than 1. The variance of a portfolio with$N$ counters is$\sigma_p^2 = \sum_{i=1}^{N} P_i^2\beta_i^2\sigma_m^2 + \sum_{i=1}^{N}\sum_{\substack{j=1 \\ i\neq j}}^{N} P_i P_j \beta_i\beta_j\sigma_m^2 + \sum_{i=1}^{N} P_i^2\sigma_{e_i}^2 = \beta_p^2\sigma_m^2 + \sum_{i=1}^{N} P_i^2\sigma_{e_i}^2$and thus, for aselected portfolio P, $\sigma_p^2 = \beta_p^2\sigma_m^2 + \sum_{i=1}^{N}\left(\frac{1}{N}\right)^2\sigma_{e_i}^2 = \beta_p^2\sigma_m^2 + \frac{1}{N}\sum_{i=1}^{N}\left(\frac{1}{N}\right)\sigma_{e_i}^2 = \beta_p^2\sigma_m^2 + \frac{1}{N}\left(\frac{1}{N}\sum_{i=1}^{N}\sigma_{e_i}^2\right)$. But$\lim_{N\to\infty}\frac{1}{N}\sum_{i=1}^{N}\sigma_{e_i}^2 = 0$.Therefore, $\lim_{N\to\infty}\sigma_p^2 = \beta_p^2\sigma_m^2 = \sigma_m^2\left(\sum_{i=1}^{N} P_i\beta_i\right)^2$, where$\sigma_m^2$, the common variance, is the measure of contribution of a security to the risk of a large portfolioβ_i. The risk on an individual security is given by $\sigma_i^2 = \beta_i^2\sigma_m^2 + \sigma_{e_i}^2$ and the influence of $\sigma_{e_i}^2$can be made smaller by combining securities so that$\frac{1}{N}\sum_{i=1}^{N}\sigma_{e_i}^2 \to 0$, implying that $\sigma_{e_i}^2$ is diversifiable or non-systematic risk. Thus, a measure of an asset's non-diversifiable or systematic risk isβ_i.

The regression techniques from the Single Index modelcan be used to estimate$\beta_i{}'s$ and$\gamma_i{}'s$. The regression equations are $\hat{\beta}_i = \frac{\sigma_{im}}{\sigma_m^2} = \frac{\sum_{t=1}^{N}\left[\left(R_{it} - E(R_{it})\right)\left(R_{mt} - e(R_{mt})\right)\right]}{\sum_{t=1}^{N}\left[R_{mt} - E(R_{mt})\right]^2}$(Jogiyanto, 2013)and$\hat{\gamma}_i = \bar{R}_i + \hat{\beta}_i\bar{R}_m$.The regression equations are not perfectly stationary over time because they are affected by changes in companies such as the capital structure changes. The excess return to beta (ERB) ratio measures the additional return on a security, beyond that offered by a riskless asset, per unit of non-diversifiable risk. The ERB ratio is estimated by $\theta_{ERB} = \frac{E(R_i) - R_f}{\beta_i}$,where $E(R_i)$ is the expected rate of return on stock i, R_f is the return on a riskless rate such as treasury bills and β_i is the risk factor for stock i as indicated in Jogiyanto(2013) and Elton,Gruber and Blake(1995).

Bayesian Regression

One procedure that has been proposed to improve on the Single Index model is to use the Bayesian estimationprocedure to estimate the risk factor, β_i. The betas in this case are assumed to be random. Given R_m a random variable with a probability density $p(R_m/\theta)$, then$L\left(\frac{\theta}{R_m}\right) = p\left(\frac{R_m}{\theta}\right)$is defined as the maximum likelihood function of θ. Of interest is to make inference about θ. The investor usually has prior belief about θ such as the probability density function$p(\theta)$. The investor defines $p(\theta)$as the prior density of θ and its conditional distribution on $R_m = r_m$ is given by$P(\theta/r_i) = \frac{p(\theta,r_m)}{p(r_i)} = \frac{p(r_m/\theta)p(\theta)}{p(r_i)} = \alpha p(r_m/\theta)p(\theta)$, where $\alpha = \frac{1}{p(r_i)}$. This is called the posterior distribution of θ. It follows that$P(\theta/r_i) = \frac{1}{p(r_i)} p(r_m/\theta)p(\theta) = \alpha L(\theta/r_m)p(\theta)$. It is clear that the likelihood function multiplied by $\frac{1}{p(r_i)}$ represents the factor by which the sample data r_m modifythe prior belief about the distribution of θ.Given R_m and R_i, both random variables, R_m is assumed to have a causal relationship with R_i. Given two vectors θ_1 and $\theta_2$with independent prior function so that $p(\theta_1, \theta_2) = p(\theta_1)p(\theta_2)$then$p(\theta_1, \theta_2/R_i, R_m) = \alpha p(\theta_1)p(\theta_2)p(R_i/R_m, \theta_2)$and integrating the equation over θ_1 gives $p(\theta_2/R_m, R_i) = \alpha p(\theta_2)p(R_i/R_m, \theta_2)$. The equation is the posterior distribution of θ_2.

Bivariate Bayesian Model

Suppose that$R_i \sim N(\gamma_0 + \gamma_1 R_m, \theta)$ and$\theta_2 = (\gamma_0, \gamma_1, \Phi)$conditional on R_m.This assumes a linear dependence of the $R_i s$ on the $R_m s$. A researcher can write$\gamma_0 + \gamma_1 R_m$ as $\alpha + \beta(R_m - \bar{R}_m)$ where $\bar{R}_m = \sum_{m=1}^{n} \frac{R_m}{n}$ from which $\gamma_0 = \alpha - \beta\bar{R}_m$ and $\gamma_1 = \beta$. This implies that$\alpha = \gamma_0 + \beta\bar{R}_m$ and can be written as$R_i \sim N(\alpha + \beta(R_m - \bar{R}_m), \phi)$ i.e. $R_i = \alpha + \beta(R_m - \bar{R}_m)$. A reference prior that is independently uniform in α, β and log(Φ) is given by$p(\alpha, \beta, \phi)\alpha\frac{1}{\phi}$. The posteriordistribution of $(\alpha, \beta, \phi)$is given by$p(\alpha, \beta, \phi/R_m, R_i) = \alpha p(\alpha, \beta, \phi)p\left(\frac{R_i}{R_m}, \alpha, \beta, \phi\right) = \alpha\phi - \left(\frac{n+2}{2}\right) exp\left(-\frac{1}{2}S_{ee} + n(\alpha - a)^2 + S_{R_m R_m}\frac{(\beta - b)^2}{\phi}\right)$, where $S_{ee} = \sum_{i=1}^{n}\left(R_i - \hat{R}_i\right)^2$ and $S_{R_m R_m} = \sum_{i=1}^{2}(R_m - \bar{R}_m)^2$. For a given b and Φ, the posterior for β is $N\left(b, \frac{\phi}{S_{R_m R_m}-}\right)$and the posterior distribution for(α, ϕ) is $p(\alpha, \phi/R_m R_i) = \alpha\phi - \left(\frac{n+1}{2}\right) exp\left[-\frac{1}{2\phi}(S_{ee} + n(\alpha - a)^2)\right]$. It can be shown that $P(\alpha, \phi) = \alpha\phi - \left(\frac{v+1}{2}\right)^{-1} exp\left[-\frac{1}{2\phi}(S + n(\theta - \bar{x})^2)\right]$ and $S^2 = \frac{S}{v}$ then $t = \frac{\theta - \bar{x}}{S/\sqrt{n}} \sim t_{v-1}$, with$v$-1 degrees of freedomand$\chi^2 \sim S^2\chi_v^2$ with v degrees of freedom(Lee, 2004). Similarly, the posterior for α given R_m and R_i is$S^2 = \frac{S_{ee}}{n-2}$is $\frac{\alpha - a}{S/\sqrt{n}} \sim t_{n-2}$and the posterior of β can be found by integrating α out of the equation to get $\frac{\beta - b}{\frac{S}{\sqrt{S_{R_m R_m}}}} \sim t_{n-1}$. The posterior equations are the*t*-distributions with *n*-2 and *n*-1 degrees of freedom respectively. A *t*-distribution is a probability distribution that arises in the problem of estimating the mean of a normally distributed population when the sample size is small. The Bivariate Bayesianmodel can improve the Single Index model's weaknesses because it does not assume systematic risk to be non-random. The Bivariate Bayesianmodelis accurate and reliable because it predicts the current market systematic risk. The Bivariate Bayesianmodel clearly states how to derive and manage risk. Thus, theBivariate Bayesianmodel was developed as an improvement of the Single Index model(Lee, 2004).

Multi-Index (Factor)Asset PricingModel

The model assumes an asset pricing model that is a linear function of many factors that are the sources of Systematic risk. Since the investors cannot diversify Systematic risk, they are compensated for bearing it. As a result, the asset's sensitivity to each factor affects the assumed asset pricing model. The sensitivity is captured by beta(Subing, Kusumah, & Gusni, 2017). The asset pricing modelis $R_{it} = \alpha_i + \beta_{1i}F_{1t} + \beta_{2i}F_{2t} + \cdots + \beta_{ki}F_{kt} + \varepsilon_{it}$, where$i$ = 1, 2,….N, t= 1, 2, …,T, $\beta_{i1}, \beta_{i2}, \dots \beta_{ik}$ are the factor sensitivities, $F_{1t}, F_{2t}, \dots F_{kt}$ are the observed factor values and ε_{it} are the random error terms. $\frac{\partial R_{it}}{\partial F_{kt}} = \beta_{ki}$, where the coefficients β_{ki} measure the change in asset i price in response to a unit increase in factor k holding all other factors constant. The model assumptions are$Cov\left(F_{jt}, \varepsilon_{it}\right) = 0$, for j = 1, 2,…,k,$Cov\left(\varepsilon_{jt}, \varepsilon_{is}\right) = 0$, for all$i \neq j$, $t$and s,$\varepsilon_{it} \sim iidN\left(0, \sigma_{\varepsilon,j}^2\right)$,$F_{jt} \sim iidN\left(\mu_{f,j}, \sigma_{f,j}^2\right)$ and $Cov\left(F_{jt}, F_{kt}\right) = \sigma_{f,ij}$. The factors $F_1, F_2, \dots, F_k$, capture the multiple risk exposure of the components and thus other variables rather than the market index may explain the asset returns. The random error ε_{it}captures the company's specific news that areunrelated to the factors' specific news. The asset pricing factors that are considered beside the market index (Elton, Gruber, & Blake, 1995) arereal GDP (or industrial production)growth rate,level of interest rates(Sunariyah, 2011; Husnan, 2009),term anddefault spread yields,inflation rate(Tandelilin, 2010),oil price'sgrowth level(Subing, Kusumah, & Gusni, 2017),return on stocks (company size)(Al Qaisi, Tahtamouni, & Al-Qudah, 2016; Enow, 2016; Füreder, Maier, & Yaramova, 2014)andreturn on portfolio of high book to market value stocks.Husnan (2009) considered the interest rate as the returning ratio of some investments while Sunariyah (2011)considered it as cost of a loan.The expected return(μ_i)on asset i is$E(R_{it}) = \alpha_i + \beta_{i1}\mu_{f,1} + \beta_{i2}\mu_{f,2} + \cdots + \beta_{ik}\mu_{f,k}$. The variance ($\sigma_i^2$)is $Var(R_{it}) = \beta_{1i}^2\sigma_{f,1}^2 + \beta_{2i}^2\sigma_{f,2}^2 + \cdots \sigma_{\varepsilon,i}^2$. The covariance ($\sigma_{ij}$) is given by$Cov\left(R_{it}, R_{jt}\right) = \sigma_{f,1}^2\beta_{1i}\beta_{1j} + \sigma_{f,2}^2\beta_{2i}\beta_{2j} + \cdots + \sigma_{f,k}^2\beta_{ki}\beta_{kj} + \left(\beta_{fi}\beta_{kj} + \beta_{ki}\beta_{fj}\right)\sigma_{f,fk}$, where the variances due to factor f, factor interaction and non-factors' news are $\beta_{fi}^2\sigma_{f,f}^2, k\beta_{1i}^2\beta_{ki}\sigma_{f,fk}$and $\sigma_{\varepsilon,i}^2$ respectively.

Industrial Index Models

The models look at the industrial and market influence on the fluctuation of the asset prices. In 1966, Kingused the Single Index model to do a forward regression procedure adding to the model industrial indices by assuming that the correlation between securities is caused by the market and industrial effects. The model is given by$R_{it} = \alpha_i + \beta_{im}I_{mt} + \beta_{1i}I_{1t} + \beta_{2i}I_{2t} + \cdots + \beta_{ki}I_{kt} + \varepsilon_{it}$,where I_{mt} is the market index and I_{it} are the industrial indices (uncorrelated with the market and among themselves).The assumption is that the industries can be grouped into homogeneous groups which in turn affect the returns of companies which influence them. Ross(1976)adopted a simpler model which states that the asset prices are influenced by the market and only one industrial index. A broad generalisation of the index models is the Arbitrage pricingtheory.

Black-Scholes Theory

Black and Scholes (1973) published on the pricing of options and corporate liabilities. The publication specified the first successful options pricing formulaandalso described a general framework for pricing other derivative instruments.The workmarked the beginning of the financial engineering field. Black and Scholes (1973)were seeking a solution to the problem of option pricing that was analogous to an existing exemplary solution, the Sharpe's(1964)Capital Asset Pricing model. The Black-Scholes theory assumesthat the stock pays no dividends during the option's life; there are no arbitrage opportunities without risk; the European exercise terms are used; the markets are efficient; there are no commissions,transactions costs and taxes that are charged; the interest rates and volatility are constant and known; the prices are log-normally distributed; the asset prices follow a geometric BrownianMotion model with a constant drift; andμ and σare the expected and volatility values respectively.

The Black-Scholes theory employs five factors to price an option on a dividend paying asset and these arethe underlying stock price (S), strike price (K),risk free rate of interest(r)(Subing, Kusumah, & Gusni, 2017), volatility (V)and time to maturity(T). The prices for a non-dividend stock European call (c) and put (p) options are$c = SN(d_1) - K\,exp(-rT)N(d_2)andp = K\,exp(-rT)N(-d_2) - SN(-d_1)$,where$d_1 = \frac{ln(S/K)+\left(r+\frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}}$, $d_2 = d_1 - \sigma\sqrt{T}$, ln is the natural logarithm and $\phi(x) = \frac{1}{\sqrt{2\pi}}\int_{-\infty}^{\infty} exp\left(-\frac{y^2}{2}\right)\partial y$. The derivatives of the Black-Scholes theory called Greeks for a call areDelta= $N(d_1)$; Gamma $= \frac{\phi(d_1)}{S\sigma\sqrt{T}}$=; Vega $= S\phi(d_1)\sqrt{T}$; Theta $= -\frac{S(d_1)\sigma}{2\sqrt{T}} - rK\,exp(-rT)N(d_2)$ andRho $= KT\,exp(-rT)N(d_2)$.The Greeks for a put areDelta $= N(d_1) - 1$; Gamma $= \frac{\phi(d_1)}{S\sigma\sqrt{T}}$; Vega $= S\phi(d_1)\sqrt{T}$; Theta $= -\frac{S\phi(d_1)\sigma}{2\sqrt{T}} - rK\,exp(-rT)N(-d_2)$andRho $= KT\,exp(-rT)N(d_2)$.

Research Methodology

The secondary panel data were collected from the Zimbabwe Statistics Agency (Zimstat) (formerly Central Statistical Office), Zimbabwe Stock Exchange (ZSE), Old Mutual Asset Managers Zimbabwe (Private) Limited and Reserve Bank of Zimbabwe(RBZ). Some data cleaning was conducted as some of the ZSE counters were deregistered whileothers were registered during the research period. Those counters were excluded because they did not have enough data points to be included in the research data analysis. The counters selected were categorized into Industrial and Mining groups. The Industrial group was composed ofX_1, X_2, X_3, X_4 and X_5counters while the Mining group was composed ofX_6, X_7 and $x_8$counters. These were the top eight movers at the ZSE during the research period. The secondary data collected included industrial and mining indices, inflation rate, money supply rate and unemployment rate. The money supply, exchange rate and interest rate (91 days treasury bills rate) data was gathered from the RBZ. The secondary datagathered has data on 12 cases, over 11 time periods, for a total of 132 observations.

The Microsoft Word XP and Equation 3.0 were used to type the whole research text and formulae respectively. Microsoft Excel XP, R 2.4.0, Intercooled Stata 7.0 and SPSS 12.0 were used to analyse the gathered research data.

Hyper-inflation Hybrid Multi-Risk Asset Pricing (HHMRAP)Framework

Themajor factors of the proposed HHMRAP framework aremoney supply,deficit spending,inflation, unemployment,overall level of interest rate, exchange rate,market index,company size and asset returns,dividend yields andhuman capital.The assumptionsare$E(\varepsilon_i) = 0; E(\varepsilon_i, F_j) = 0; Var(F_j) = \sigma_{F_j}^2; Var(\varepsilon_i) = \sigma_{\varepsilon_i}^2; Cov(F_i, F_j) = \sigma_{F_{ij}}$;stock returns are normally distributed;all relevant information regarding assets are freely available to all investors;all assets including human resources are marketable; andall investors have rational expectations. The HHMRAP framework's notations are $\tilde{R}_i$is the adjusted rate of return on counter i;α_i is the expected value of the unique returns;β_{ik} is the measure of the sensitivity of the company's asset returns on the market;$\varepsilon_i$is a random component of the unique return, with zero mean and variance$\sigma_{\varepsilon_i}^2$;$\tilde{R}_{im}$is the adjusted market return measured by Industrial and Mining indices;$I_r$is the rate of inflation;$r_f$is the relative monthly rate in risk free interest rate as depicted by the treasury bills yields;E_r is the monthly rate of the exchange rate of the Zimbabwean Dollar (ZW$) against the United States Dollar (US$);$M_3$ is a measure of the monthly rate of supply of money in the economy of Zimbabwe;and$U_r$is the monthly unemployment rate of Zimbabwe. Thus, the Hyper-inflation Hybrid Multi-Risk Asset Pricing (HHMRAP) model is given by:

$$\tilde{R}_i - r_f = \alpha_i + \beta_{i1}(\tilde{R}_{im} - r_f) + \beta_{i2} I_r + \beta_{i3} r_f + \beta_{i4} E_r + \beta_{i5} M_3 + \beta_{i6} U_r + \varepsilon_i, \qquad (1)$$

The indices are usually correlated, thus the Principal Componentmethod can be used to make them orthogonal. In such a case,Equation 1becomes:

$$R_i = \alpha_i + \beta_{i1} R_{im} + \beta_{i2} I_2 + \beta_{i3} I_3 + \beta_{i4} I_4 + \beta_{i5} I_5 + \beta_{i6} I_6 + \varepsilon_i, \qquad (2)$$

where$R_i = \tilde{R}_i - r_f$, $R_{im} = \tilde{R}_{im} - r_f$ and all I_js are uncorrelated indices. It is desirable for $E\{\varepsilon_i[I_j - E(I_j)]\} = 0$, for $j = 1, 2, \ldots. N$. The expected return on asset i is given by:

$$E(R_i) = \alpha_i + \beta_{11} E(R_{im}) + \sum_{j=2}^{6} \beta_{ij} E(I_i) = \alpha_i + \sum_{j=1}^{6} \beta_{ij} E(I_i), \qquad (3)$$

The variance of the asset *i* is given by:

$$Var(R_i) = \beta_{11} \sigma_{im}^2 + \sum_{j=1}^{6} \beta_{ij}^2 \sigma_{Ij}^2 + \sigma_{\varepsilon i}^2 = \sum_{j=1}^{6} \beta_{ij}^2 \sigma_{Ij}^2 + \sigma_{\varepsilon i}^2, \qquad (4)$$

The covariance between stocks *i* and *t* is given by:

$$Cov(R_i, R_j) = \beta_{11}\beta_{t1}\sigma_{I1}^2 + \sum_{j=1}^{6} \beta_{ij}\beta_{tj}\sigma_{Ij}^2 = \sum_{j=1}^{6} \beta_{ij}\beta_{tj}\sigma_{Ij}^2, \quad (5)$$

The Application Procedureof the HHMRAPFramework

The assumptions were tested before the proposedHHMRAPframework(in Equation 1)was applied to analyse the gatheredresearch data.The research data was used to investigate the capacity of the HHMRAP frameworkto estimate the asset prices in an inflationary environment. The mean of the unique returns was 0.018887. The expected return was computed with Equation 3 and the variance was computed with Equation 4.The F_{tab} at 10%, 5%and 1%levels of significance and the test statistic (F_{calc}) are compared. If $F_{tab} > F_{calc}$, the regressor is considered to be significant; otherwise it is insignificant.

Results and Discussions

The HHMRAPframework(in Equation 1) was applied to analyse the research data for the eightcounters and the computed results are presented in Table 1.

Table 1: Analysis of the Counters using the HHMRAP Framework

Counter	β_0	β_1	β_2	β_3	β_4	β_5	β_6	Adjusted R^2	F-Value	D-W Statistic
X_1	-0.523 (-1.378)	-0.002 (-0.217)	-1.019 (-0.385)	-1.681 (-1.594)	-0.038 (-0.400)	-0.017 (-0.052)	0.104 (1.744)	0.001	1.024	2.101
X_2	-0.043 (-0.665)	-0.001 (-0.847)	-0.333 (-0.739)	-1.031 (-5.741)	-0.019 (-1.159)	0.013 (0.229)	0.017 (1.662)	0.218	7.078	1.767
X_3	-0.122 (-0.820)	-0.002 (-0.566)	1.209 (1.165)	0.421 (1.020)	-0.063 (-1.675)	0.039 (0.310)	0.019 (0.834)	0.026	1.577	1.643
X_4	0.065 (0.278)	0.003 (0.442)	-0.680 (-0.414)	-0.783 (-1.199)	-0.029 (-0.491)	0.003 (0.017)	0.012 (0.332)	0.086	0.450	2.164
X_5	-0.022 (-0.179)	0.001 (0.329)	2.648 (2.827)	-1.225 (-3.524)	-0.012 (-0.380)	0.041 (0.386)	-0.002 (-0.095)	0.121	3.993	1.849
X_6	-0.081 (-0.844)	0.004 (0.096)	1.007 (1.496)	-1.164 (-4.347)	-0.001 (-0.037)	0.020 (0.248)	0.015 (0.985)	0.126	4.145	1.997
X_7	0.100 (0.211)	-0.022 (-0.105)	10.178 (3.056)	-2.003 (-1.511)	-0.011 (-0.094)	0.136 (0.333)	-0.056 (-0.750)	0.053	2.231	2.253
X_8	-0.067 (-0.599)	0.059 (1.221)	1.917 (2.431)	-1.210 (-3.855)	0.011 (0.368)	0.102 (1.055)	0.006 (0.346)	0.133	4.340	1.773

The results in Table 1 were computed from 132 monthly observations for the first eight movers counters for the period January 1994 to December 2004. The Durbin Watson (D–W) statistics and *t*-statistics are in parentheses. When the independent variables are compared on an individual basis, the only variables that are significant at 1%, 5% and 10% levels of significance are the exchange rate, inflation, money supply and unemployment in X_6 and X_8. The results support the findings by (Subing, Kusumah, & Gusni, 2017) on the impact of systematic risk and interest on stock prices. Inflation is insignificant in X_5 and X_7 at all three levels of significance. The results contradict Krishna and Wirawati(2013)but support the findings by Zukarnaen, Samsung and Mauling (2016),Augustine and Sumartio, Amin (2014) and Kewal (2012) on the relationship between inflation and stock prices. However, Subbing et al. (2017)stated that inflation rate can have both positive and negative effect depending on the rate of inflation. The miningindex and treasurybills are insignificant in the three models of the mining companies. All the counters have no autocorrelation in the variables since the D-W statistics are greater than one.

Table 2:HHMRAP Estimated Rate of Return andRisk for the Counters

Counter	Pooled Ordinary Least Square		Cross Section Time Series			
	$\sigma_{\varepsilon i}$	E(R)	Sigma_u	Sigma_e	Rho(ρ)	R-Squared
X_1	1.2742560	0.828281	0.37915343	1.3099279	0.07730266	0.0432
X_2	0.2170554	0.128670	0.08235767	0.21720307	0.12570036	0.2701
X_3	0.3237461	0.206313	0.10539516	0.33047528	0.09232006	0.1917
X_4	0.4989110	0.293249	0.17536061	0.50477942	0.10769026	0.0838
X_5	0.7896333	0.136558	0.26855500	0.80127140	0.10098861	0.0236
X_6	0.4198547	0.179268	0.12494738	0.43213120	0.07715299	0.1511
X_7	1.6019070	0.299566	0.42558788	1.6622026	0.06152257	0.0782
X_8	0.3793676	0.203225	0.14976041	0.37681743	0.13640823	0.1767

Table 2 shows that the counter with the highest risk bears the highest expected rate of return. The mean of the unique returns is 0.018887. The expected return was estimated by Equation 3 and the variance byEquation 4. The X_1 counter had the highest risk of 1.2742560 and the highest rate of return of 82.28% among the counters. The X_2counter had the least risk and rate of return of 0.2170554 and 12.87% respectively. The X_7counter's risk and expected rate of return are 1.6019070 and 29.96% respectively. The results are similar to the findings by Amanda and Pratomo (2013) and Rahmi, Arfan andJalaluddin (2013).The HHMRAP framework performed to the expected level; the higher the risk associated with an asset, the higher the expected rate of return from investing in that asset.

Table 3:HHMRAP Adjusted Returns against S&D Adjusted Returns

Year	Month	HHMRAP Adjusted Returns			S&D Adjusted Returns		
		X_1	X_4	X_5	X_1	X_4	X_5
2005	January	0.218599	0.146867	0.215886	0.013699	0.064516	0.538462
	February	0.148974	0.312920	0.132697	-0.081081	0.454545	0.250000
	March	0.054848	0.227576	0.098932	0.205882	0.875000	0.400000
	April	0.022568	0.267758	0.100417	0.121951	0.444444	0.085714
	May	-0.509448	0.373277	-0.076850	-0.130435	0.461538	0.000000
	June	-0.494825	0.243752	-0.046301	-0.150000	0.315789	-0.078947
	July	-0.781315	0.307393	-0.038638	0.985294	-0.040000	1.428571
	August	-0.390937	0.336275	-0.040969	0.037037	0.041667	-0.035294
	September	-0.518762	0.262684	0.003867	1.428571	0.000000	-0.219512
	October	-0.167554	0.546397	0.099354	0.658824	-0.340000	1.031250
	November	-0.337569	0.400983	0.057649	-0.326241	0.212121	0.461538
	December	-0.419630	0.422869	-0.019710	0.052632	0.000000	0.736842

To check the performance of the HHMRAP framework against the Supply and Demand (S&D)theory, the research computed the forecasts for the rate of returns for X_1, X_4 and

X_5 counters. Table 3 shows the rate of returns when the HHMRAPframeworkand S&D theory were used to determine the asset prices at the ZSE for the period January to December 2005. The differences shown by the two outputs show that the HHMRAPframework was not affected by the hyper-inflation that the economy of Zimbabweexperienced since itincorporated its effect in determining the asset rate of returns. This is shown by the negative rate of returns estimated by the HHMRAPframework to the positive rate of returns determined by the S&D theory. Therefore, selecting theappropriateasset pricing models impactspositively on companies' profitability (De Tonia, Milan, Saciloto, & Larentis, 2017).

Conclusion and Recommendations

The HHMRAPframework performed exceptionally well in pricing listed stocks and managing risk in unstable and unpredictable economic conditions. The S&Dtheoryis the most appropriate asset pricing model for listed stocks under normal economic conditions.Since there was corruption, high inflation and unstable interest rates, unpredictable exchange rates (fixed and parallel markets) and high unemployment rate, the asset pricing model required some panel beating if not replacement and can be applied when the storm subsided. The asset pricing enterprise is a very complex financial transaction considering the number of asset pricing models that have been so far proposed in an attempt to find a perfect and accurate model in different economic conditions. However, when compared to non-listed stocks for which most current financial pricing models were originally developed for, the listed stocks are very complex to price. The complexity means that the models that are readily available to price non-listed stocks cannot necessarily provide acceptable results when applied to price listed stocks. Thus, the S&Dtheory will continue to rule at listed stock markets despite that under harsh economic conditions,it was found to be under-estimating the value of the assets.

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References

Agustina, & Sumartio, F. (2014). Analysis of Factors Affecting Stock Price Movements in Mining Companies. *Wira Ekonomi Mikroskil Journal, 4*(1), 51 - 61.

Al Qaisi, F., Tahtamouni, A., & Al-Qudah, M. (2016). Factors Affecting the Market Stock Price - The Case of the Insurance Companies Listed in Amman Stock Exchange. *International Journal of Business and Social Science, 7*(10), 81 - 90.

Amanda, & Pratomo. (2013). Fundamental Analysis and Systematic Risk to Banking Stock prices Listed in Index of LQ 45. *Economic and Finance Journal, 1*(3), 205 - 219.

Black, F., & Scholes, M. (1973). The pricing of Options and Corporate Liabilities, . *The Journal of Political Economy, 81*(3), 637 – 654.

De Tonia, D., Milan, S. G., Saciloto, E. B., & Larentis, F. (2017). (2017). Pricing strategies and levels and their impact on corporate profitability. *Revista de Administração, 52*, 120 - 133.

Elton, E. J., Gruber, J. M., & Blake, R. C. (1995). Fundamental Economic Variables, Expected Returns, and Bond Fund Performance. *The Journal of Finance, 50*(4), 1229 - 1256. doi:10.2307/2329350

Enow, S. T. (2016). Determinants of Share Prices: the Case of Listed Firms on Johannesburg Stock Exchange. *Journal of Accounting and Management, 6*(1), 85 - 92.

Farrel, L. J. (1997). *Portfolio Management: Theory and Application* (2nd ed.). McGraw-Hill.

Füreder, R., Maier, Y., & Yaramova, A. (2014). Value-based pricing in Austrian medium-sized companies. *Strategic Management, 19*(10), 13 - 19.
Husnan, S. (2009). *Fundamentals of Portfolio Theory and Analysis of Securities.* Yogyakarta: UPP STIM YKPN.
Jogiyanto, H. M. (2013). Portfolio Theory and Investment Analysis . *BPFE Yogyakarta, Edisi Kedelapan, Yogyakarta*.
Kewal, S. S. (2012). *The Effect of In¬flation, Interest Rate, Exchange Rate, and GDP Growth to Composite Stock Price Index.* Palembang: Institute of Economic Science Musi.
Lee, P. M. (2004). *Bayesian Statistics, An Introduction* (3rd ed.). London, England: Arnold.
Markowitz, H. (1952). Portfolio Selection. *Journal of Finance, 7*(1), 77 - 91.
Murairwa, S. (2007). *Comparison of Asset Pricing and Risk Management Techniques (M.Sc. Dissertation).* National University of Science and Technology (NUST), Applied Mathematics, Bulawayo, Zimbabwe.
Rahmi, A., Arfan, M., & Jalaluddin. (2013). The Effect of Fundamental Factors and Systematic Risks to Stock Prices (Study on Manufacturing Companies Listed on Indonesia Stock Period 2007–2009). *Accounting journal, 2*(2), 1 - 15.
Ross, S. (1976). The arbitrage theory of capital asset pricing. *Journal of Economic Theory, 13*(3), 341 - 360.
Sharpe, W. F. (1964). Capital Asset Prices; A Theory of Market Equilibrium under Conditions of Risk. *Journal of Finance, 19*(3), 425 - 442.
Subing, H. J., Kusumah, R. W., & Gusni. (2017). An Empirical Analysis of Internal and External Factors of Stock Pricing: Evidence from Indonesia. *Problems and Perspectives in Management, 15*(4), 178 – 187.
Sunariyah. (2011). *Introduction to Capital Market Knowledge* (6th ed.). Yogyakarta: UPP STIM YKPN.
Tandelilin, E. (2010). *Portfolio and Investment: Theory and Application* (1st ed.). Yogyakarta: Kanisius.
Wirawati, & Krisna. (2013). The Effect of inflation, rupiah exchange rate, interest rate of SBI at composite stock price index in Indonesia Stock Exchange. *Journal of Economics and Management, 30*(1), 202 – 214.
Zulkarnaen, A. H., Syamsun, M., & Maulana, T. N. (2016). Analysis of Fundamental and Technical Fac¬tors to Stock Price on Residential Property Sector Companies Listed in Indonesia Stock Exchange. *International Journal of Scientific and Research Publications, 6*(12), 315 – 319.