INTERNATIONAL JOURNAL OF ECONOMICS AND FINANCE STUDIES
Vol: 14 **No: 0**3 **Year:** 2022 **ISSN**: 1309-8055 (Online) (**pp.** 168-210) **Doi:** 10.34109/ijefs. 20220069
Received: 21.06.2022 | **Accepted:** 12.10.2022 | **Published Online:** 01.11.2022

-RESEARCH ARTICLE-

EVALUATING THE USEFULNESS OF THE DEA MODEL TO IDENTIFY RATIOS THAT CAN EXPLAIN SOUTH AFRICAN STOCK MARKET RETURNS

Chris van Heerden

Professor in Finance in the School of Economic Sciences,
North-West University, South Africa
Email: chris.vanheerden@nwu.ac.za
https://orcid.org/0000-0001-8074-0719

Wilmé van Heerden

Lecturer in Finance in the School of Economic Sciences,
North-West University, South Africa
Email: 21665052@nwu.ac.za
https://orcid.org/0000-0003-1737-6007

─Abstract─

How to successfully identify ratios that will ensure profitable share selections remains a fundamental question in finance, as the literature has failed to promote a conclusive methodology. This study addressed this issue by being the first to prove that the multi-stage DEA model is a viable ratio selecting tool. The DEA model can capture the interdimensional relationships present and uncover relationships that are unknown to other methodologies (Cooper et al., 2007; Kumar et al., 2014). Data availability limited the study to evaluate 27 financial ratios and variables and 25 risk-adjusted performance ratios' post-financial crisis explanatory abilities of 176 JSE listed companies. By consulting only, the efficiency scores generated from multiple multi-stage DEA regressions, and after eliminating correlation in portfolio compositions, results indicated that the Calmar ratio should be considered by both passive and active investor. This ratio demonstrated dominance in share selection, leading to market-outperforming portfolios from both a 1-, 3-, and 5-years momentum investment strategy perspective, respectively. In conjunction with the Calmar ratio, preliminary results suggested ratio compositions that differed over time and across sectors and industries. These findings violate the

Citation (APA): Heerden, C. V., Heerden, W. V. (2022). Evaluating the Usefulness of the Dea Model to Identify Ratios that Can Explain South African Stock Market Returns. *International Journal of Economics and Finance Studies, 14* (03), 168-210. doi:10.34111/ijefs. 20220069

modern portfolio theory assumption of an efficient market and accentuate the importance of consulting time-varying market efficiency during the process of share selection, as market-outperforming decisions are possible.

JEL Classification: G10, G11.

Keywords: DEA; financial ratios; JSE, risk-adjusted performance ratios.

1. INTRODUCTION

The pioneer work of Markowitz (1952) originally formulated the concept of portfolio selection in a mean-variance quadratic optimisation model, which later conceptualised into the foundation of modern portfolio theory. This mean-variance approach rest on the construction of a frontier relative to which portfolio performance is measured (Tarnaud et al., 2018). Parallel to this, operational and economic research also developed a frontier methodology for measuring the performance of decision-making units (DMUs)[1], by means of a non-parametric, non-stochastic, mathematical programming framework. This framework, also known as the Data Envelopment Analysis (DEA) model, was originally introduced by Tarnaud et al. (2018), from a limited constant returns to scale (CRS)[2] perspective. Though, it was Banker et al. (1984) who provided a solution for this limitation by developing the variable returns to scale (VRS)[3] model. This model is based on the work of Shephard (2012) allows for possibilities such as capacity limitations on inputs.

The junction between the quadratic optimisation methodology of portfolio selection research and the DEA methodology inherited from operational research was not recognised until Sengupta (1989) and Murthi et al. (1997) emphasised the plausibility of utilising this non-parametric approach as an investment management tool. Over time the DEA model raised to the challenge by becoming a powerful measurement tool. It can assist in portfolio selections when a performance measurement of a company (input) is used to explain the company’s outcome or production (output) Amin et al. (2021). This model has been credited for being able to acknowledge interdimensional relationships (Cooper et al., 2007), and able to uncover relationships that are unknown to other methodologies (Kumar et al., 2014). As a result, there has been an increasing array of literature that further highlighted the prominence of the DEA’s application in finance (see for example, Premachandra et al. (1998); Morey et al. (1999); Gregoriou et al. (2005); Pätäri et al. (2010); Liu et al. (2013); Van Heerden et al. (2013); Tarnaud et al. (2018); Amin et al. (2021).

---

[1] In the field of operational research decision-making units are the firms under evaluation. However, in this study it will be the ratios under evaluation as summarised by Table 1.
[2] See Coelli (1998) for a more detailed explanation.
[3] See Coelli et al. (1998) for a more detailed explanation.

Vol: 14 **No:** 03 **Year:** 2022 **ISSN**: 1309-8055 (Online) (**pp.** 168-210) **Doi:** 10.34109/ijefs. 20220069

This study extended the literature by being the first to introduce the multi-stage DEA model as a ratio selecting tool. Due to the inability of the literature to reach a consensus on which set of financial and/or risk-adjusted performance ratios can be considered as being 'all-inclusive' and ideal for share selection, and with no methodology prescribed by the literature to successfully identify such ratios, presented the opportunity for this novel study. Since share selection can be considered as a multi-criteria decision-making process (Powers et al., 2000), previous DEA model application studies that have failed to acknowledge this 'multi-criteria nature' through their input-output selection process may have reported inadequate efficiency scores[4]. Consequently, these scores are dependent and limited to the input and output dimensions specified in each study (Berg et al., 1991).

For this reason, this study was addressed solely from a fundamental analyst's perspective by making use of multiple multi-stage DEA regression, where each regression had only one criterion – evaluating the explanatory ability of an individual ratio. Afterwards, through a comparison study, this study establish which single ratio or group of ratios can help to construct market-outperforming portfolios from a momentum investment strategy perspective. The novelty of this study can also be highlighted by the literature, where past DEA application studies are limited to identifying undervalued shares; measuring share performance; assisting in portfolio selections (see for example, Abad et al. (2004); Powers et al. (2000); Ho et al. (2010); Amin et al. (2021), respectively); or evaluating investment fund performance and the performance of fund management strategies (see for example, Morey et al. (1999); Gregoriou et al. (2003); Haslem et al. (2003); Premachandra et al. (1998), respectively).

This study utilised the multi-stage DEA model's ability to acknowledge the interdimensional relationships between ratios (inputs) and Johannesburg Stock Exchange (JSE) returns (outputs). From an input-orientated perspective, the multi-stage DEA model was applied in multiple regressions to evaluate the individual ability of each of the 27 financial ratios[5] and variables and 25 risk-adjusted performance ratios[6] under evaluation. Each multi-stage DEA regression entailed applying only one ratio or variable as the input variable and the share returns of the 176 JSE-listed companies under evaluation as the output variable. This approach was duplicated for three different output scenarios, to incorporate both an active and passive investor's investment horizon. These output scenarios entailed examining the ability to explain the in-sample, ex post future

[4] The concept of efficiency in this study refers to the ability of ratios to explain in-sample, ex post future realised share returns. The level of efficiency (efficiency scores) is measured on a scale of 0 to 1, where a value of 1 indicates that the ratio has superior explanatory abilities, and a value closer to 0 indicates that the ratio has poor explanatory abilities.

[5] Financial ratios are perceived to represent a firm's financial performance characteristics, which are used by fundamental analysts to forecast the future rate of return (Barnes, 1987; Ross et al., 2014).

[6] Risk-adjusted ratios were originally developed to measure portfolio performance. These ratios measure the returns an investment will provide given the level of risk associated with it (Reilly, 2018).

realised returns over a 1-, 3-, and 5-years investment horizon, respectively. This enabled the evaluation of not only each ratio's explanatory ability, but its potential to predict future share returns.

The ratios or variables with the greatest consolidated ability to explain both 1-, 3-, and 5-years in-sample, ex post future realised share returns (or highest efficiency scores) were identified, which were utilised to construct equally weighted equity portfolios. Three portfolios for each ratio or variable were constructed (each portfolio was based on one of the three different output scenarios), which consisted of 10 shares, based on the companies who's returns could be best explained (highest efficiency scores). The portfolios that were derived from the best ratios or variables were then evaluated over a 1-, 3-, and 5-years momentum investment strategy, respectively, to establish which ratio or variable had the ability to identify shares that will ultimately lead to market-outperforming portfolios. Lastly, portfolios performance and a correlation evaluation were consulted to assist during the elimination process, thereby eliminating poor performing and highly correlated portfolios. This enabled the ability to identify the most ideal ratio or ratio combinations that would be suitable for both passive and active investors. The correlation evaluation is necessary, as ratios tend to provide overlapping information that can lead to identical or similar portfolio compositions and rankings (Chen et al., 1981; Eling et al., 2007; Trejo Pech et al., 2015; Van Heerden, 2015).

The selection of ratios, variables and companies under evaluation were guided by the literature and data availability, where the latter were sourced from IRESS (2022). The purpose and scope of this study will be limited to evaluating the multi-stage DEA model's ability to identify ratios that will lead to portfolio compositions with the ability to outperform the market. This implies that attempts to improve portfolio optimisation or portfolio allocation; identifying undervalued shares; or the testing of any type of diversification technique fall outside the scope of this study. Additionally, the importance of a comparison study between DEA and other methodologies is acknowledged but suggested for future studies. This study only serves as an introductory evaluation in the DEA's ability to assist investor's decision-making process. This study also does not claim the DEA model as a stand-alone investment tool, only highlighting its ability to discriminate between strong performing ratios and others. In conclusion, the results from this study verified the multi-stage DEA model's ability to identify a combination of ratios that will enable investors to construct market-outperforming portfolios, a feat that has been unacknowledged by academicians and practitioners until now.

To accomplish this goal, this paper will have the following structure: Section 2 will provide additional background on the DEA model and the motivation for the use of the multi-stage DEA model. Section 3 provides a literature background on ratio selections. Section 4 describes the data used, whereas Section 5 reports the findings; and finally, Section 6 provides the recommendations and conclusions.

2. THE MULTI-STAGE DEA MODEL

In the field of operational research Farrell (1957) originally proposed that the level of efficiency can be measured by means of an equi-proportionate reduction in current inputs to produce predetermined levels of outputs. This led to the development of several approaches to efficiency and productivity analysis. Among these are the non-parametric, non-stochastic, mathematical programming framework, called the DEA model (Charnes et al., 1978) and the Stochastic Frontier (Aigner et al., 1977; Meeusen et al., 1977), which are considered as the two pioneering contributions (Sharma et al., 1997).

The DEA model does not address the problem of output assessment but seeks to combine multiple inputs and outputs in a single, non-arbitrary, non-subjective manner via the criterion of Pareto efficiency, without requiring specification of any priori weights (Nunamaker, 1985). It focuses on observed best-practice frontiers rather than on central tendency properties of frontiers and requires no assumptions of a functional form relating inputs to outputs. On the contrary, the Stochastic Frontier requires one to impose an explicit functional form for the underlying technology and an explicit distributional assumption for the inefficiency term (Sharma et al., 1997). This can pose a problem when investing in emerging markets on exchanges such as the JSE, where the presence of higher moments (deviation from a normal distribution) has been established (Bekaert et al., 1998; Van Heerden, 2015). Furthermore, the DEA model can accommodate multiple inputs and outputs without the need for homogeneous measurement units. It can also adjust for exogenous variables that are beyond the control of DMUs and provides insight into the input and output quantities that inefficient DMUs must achieve to be deemed efficient (Charnes et al., 1978; Nunamaker, 1985). These arguments justify the notion, that the DEA model may be considered as the more suitable model for this type of study (see also Table 1 for more evidence).

From an efficient frontier perspective, the DEA identifies the inefficiency of a DMU by comparing it to similar efficient DMUs. Implying that it benchmarks the non-best practices with best practices to determine the extent of inefficiencies (Avkiran, 1999; Jaforullah et al., 1999). For example, the solid line from Figure 1 that envelops all inefficient DMUs but passes through efficient DMUs L, M, N, depicts the efficient frontier and represents achieved efficiency. Inefficient DMU K, as part of a sample of ten units, needs to move to K' on the frontier to be deemed efficient. In this example DMU K would be directly compared to units M and N on the efficient frontier to calculate its efficiency scores, where units M and N represent DMU K’s reference set or peer group. However, according to Figure 1 DMU M would make a greater contribution to DMU K’s efficiency score compared to DMU N, as DMU M lies closer to the inefficient DMU K (Avkiran, 1999). With the equivalence of a maximum likelihood estimation (Banker, 1993), the DEA model’s estimators are consistent, unbiased, and possesses the ability to converge faster compared to other frontier methods. It also has no assumption of any underlying model or reference technology (Grosskopf, 1996;

Vol: 14 **No:** 03 **Year:** 2022 **ISSN**: 1309-8055 (Online) (**pp.** 168-210) **Doi:** 10.34109/ijefs. 20220069

Kittelsen, 1999). The popularity of the DEA model is motivated by its flexibility, its capability to handle non-commensurate multiple inputs and outputs simultaneously (Kirirgia et al., 2001; Nunamaker, 1985), and its ability to address both qualitative and quantitative and data, including discretionary and non-discretionary inputs (Golany et al., 1999).

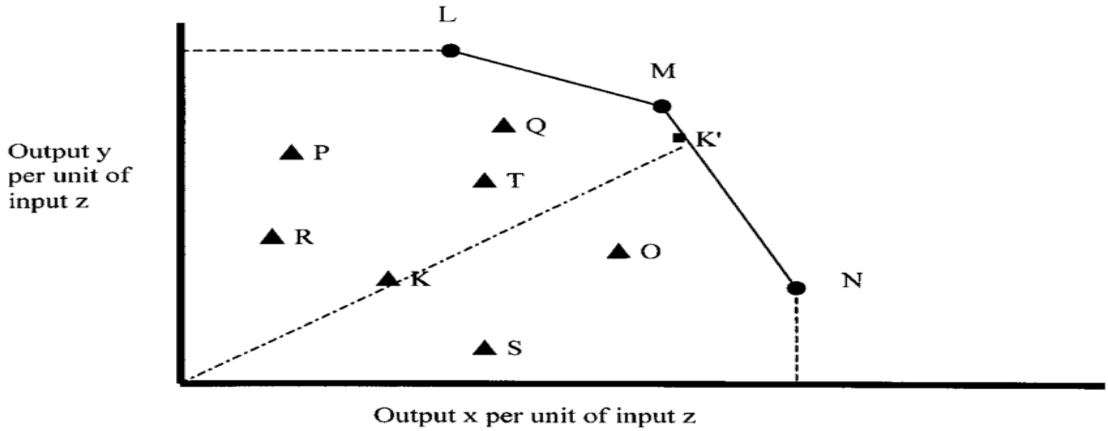

Figure 1: Illustrating the Efficient Frontier through a One-Input, Two-Output DEA Model
Source: Avkiran (1999)

However, different variations and extensions to the DEA model have been widely published in different fields, making the choice of the ideal version a daunting task. Despite that, the literature has yet to reach a consensus on model superiority and no evidence has up till now been provided to support the notion to adapt a different model to accomplish the feat as set out in this study. This study therefore adopted Coelli (1998)'s multi-stage DEA version, as it overcomes two main shortcomings of the commonly used two-stage linear programming (LP) process. First, the two-stage LP process maximises the sum of slacks, where it should minimise it; and it identifies the furthest efficient point, where it should identify the nearest point. Second, the two-stage LP process is not invariant to the units of measurement (Coelli et al., 1998; Lovell, 1995). The multi-stage DEA model was estimated by means of the DEA Frontier software, a DEA add-in for Microsoft® Excel developed by Zhu (2016).

3. LITERATURE BACKGROUND ON RATIO SELECTIONS

The intuitive work of Sharpe (1966), Lintner (1969), Mossin (1966) and Black (1972) brought together the Sharpe-Lintner-Black (SLB) asset pricing model that paved the risk-return outlook for both practitioners and academics. This model "embodies a theory of what can be inferred about expected returns when markets are in equilibrium, homogenous expectations prevail and when all investors pursue a mean-variance optimizing objective" (Van Rensburg, 2001). Fundamentally, the SLB model argues that the market portfolio is mean-variance efficient (Markowitz, 1952), implying that: (1)

market betas are sufficient to describe the cross-section of expected returns; and (2) expected returns are a positive linear function of market betas (Fama et al., 1992).

However, several empirical contradictions, such as the presence of capital market anomalies (Araújo et al., 2018) and the inconsistency in the presence of market anomalies (Schwert, 2002) rendered the traditional SLB model unreliable. In an attempt to improve the SLB model's explanatory ability past research considered incorporating proxies that not only represented firms' characteristics, but signified the importance of acknowledging market anomalies. For example, Banz (1981) and Bhandari (1988) argued that by adding a size and leverage effect proxy to the model will aid market betas in explaining average returns. However, over time the literature provided evidence to support the notion of considering also other ratio alternatives. For example, some studies reported that the DuPont model, implied dividend growth rate, dividend yield (DY), price-to-net-asset-value (NAV), pay-out, cash-flow-to-price, book-to-market, price-to-earnings (P/E), and the retained earnings-to-market ratios, and other profitability measures exhibited prevailing explanatory abilities see for example (Asness et al., 2000; C Auret et al., 2011; CJ Auret et al., 2006; Balakrishnan et al., 2010; Ball et al., 2020; Basiewicz et al., 2010; Berzkalne et al., 2014; Chan et al., 1991; Fama et al., 2017, 2018; Hoffman, 2012; Hou et al., 2011; Johannes et al., 2014; Lakonishok et al., 1994; Litzenberger et al., 1979; McMillan, 2019; Rensburg et al., 2003; Rosenberg et al., 2021; Sanjoy, 1983; Soliman, 2008; Stattman, 1980; Traub, 2001; Van Rensburg, 2001; Zaremba et al., 2017).

Even with this evidence reported above, it is argued that financial ratios tend to comprise overlapping information, making it challenging to compile a small representative (all-inclusive) group of ratios (Chen et al., 1981; Trejo Pech et al., 2015). Also, the presence of time-varying efficiency, and varying efficiency levels across different indices (Heymans et al., 2018) contributed to the understanding of why the literature has still failed to identify an all-inclusive group of ratios and why ratios lack continuity in their explanatory abilities over time. Additionally, financial ratios are considered to be backwards-looking, lacking the ability to reflect future consequences of managerial actions (Clark, 1997). This can be due to their: (1) inability to represent the many facets of performance and to explain the reasons for 'good' or 'bad' performances (Avkiran, 1997); (2) inability to capture the interplay amongst the multiple resources and outputs of a company (Davenport et al., 1987); (3) reliability on internal historical data and the sensitivity to manipulation (Van Heerden et al., 2013); and (4) inability to always consider the risk associated with the investment or company (Gadoiu, 2014). To overcome these shortcomings equity analysts are advised to consider the use of non-financial measure methodology to identify ratios, namely the multi-stage DEA model. This is based on the evidence that non-financial measures are: (1) considered to be a more reliable source of information on firm failure; (2) being better predictors of long-term performance; and (3) less prone to manipulation (Ames et al., 2012; Johnson et al., 1987; R. S. Kaplan et al., 1996; Singleton-Green, 1993).

Vol: 14 **No: 0**3 **Year:** 2022 **ISSN**: 1309-8055 (Online) (**pp. 1**68-210) **Doi:** 10.34109/ijefs. 20220069

4. DATA

This study applied a South African approach, where companies under evaluation are listed on the JSE. The JSE is ranked 18th in the world and is characterised by a considerable level of volatility. However, despite the latter, the developed world continues to diversify their portfolios by including equities from emerging marks, like the JSE (Ocran, 2010). The attractiveness of the JSE can be justified by Table 1, which reports a comparison descriptive study between the JSE All Share index and some of the world's largest stock indices from January 2010 to December 2020. Although the JSE All Share index exhibited the 5th largest mean, it competed well against other indices in terms of volatility (standard deviation), where it exhibited the second lowest level. From a risk-adjusted return perspective (mean divided by the standard deviation), the JSE All Share index exhibited the 4th highest level, which signifies the attractiveness of this index and explains why it can be considered by world portfolio managers. Especially because the JSE All Share index outperformed indices like the CBOE UK 350, NYSE Composite, Hang Seng, and Shanghai SE Composite, respectively, which dominate in terms of market capitalisation.

It is also interesting to note that higher moments were present in all indices, which signify the presence of non-normal distributions, as reported by the Shapiro-Wilk, Lilliefors, Jarque-Bera, and Kolmogorov-Smirnova normality tests, respectively. This further justifies the notion to use the DEA instead of the Stochastic Frontier, as the latter requires one to impose an explicit functional form for the underlying technology and an explicit distributional assumption for the inefficiency term (Sharma et al., 1997). With Table 1 providing provisional findings to prove the JSE's viability as an investment arena to be considered by world portfolio managers, it is important to assist the process of portfolio diversification by illustrating which ratios or variables can be utilised to identify the ideal shares to consider. This study is limited by data availability, where only 176 listed companies could be evaluated over a time span from 2010 to 2020. The selection of ratios, variables and listed companies were also based on data availability. Nevertheless, the credibility of the chosen ratios and variables were still verified by the literature, as summarised by Table 2.

Most of the companies under evaluation originated from the financial services and mining sectors, followed by the general retailers and real estate investment trusts sectors, respectively (see Figure 2). However, when considering the new Industry Classification Benchmark (ICB), as reported by FTSE Russell (2021), most of the companies under evaluation originated from the financials and industrial industries, followed by basic materials and consumer discretionary, respectively (see Figure 3). This may be considered as one of the shortcomings of this study, as data availability and the composition of the JSE led to an unequal comparison of sectors and industries.

Vol: 14 **No:** 02 **Year:** 2022 **ISSN**: 1309-8055 (Online) (**pp.** 686-730) **Doi:** 10.34109/ijefs. 20220059

Table 1. Descriptive Statistics on Index Returns: A Comparison Study Between the JSE and Some of The World's Largest Stock Indices from January 2010 to December 2020

Statistic	JSE All Share	NASDAQ Composite	NYSE composite	Frankfurt DAX	CBOE UK 350
Minimum	-10.23%	-13.15%	-12.60%	-13.05%	-10.13%
Maximum	7.26%	8.93%	9.56%	10.41%	7.56%
Median	0.06%	0.11%	0.06%	0.08%	0.03%
Mean	0.03%	0.06%	0.02%	0.03%	0.02%
Standard deviation (For population)	1.07%	1.23%	1.13%	1.30%	0.99%
Risk-adjusted returns	2.57%	5.04%	2.20%	2.27%	2.25%
Skewness (Pearson)	-0.67	-0.74	-1.03	-0.55	-0.71
Kurtosis (Pearson)	7.94	10.77	16.05	7.78	9.14
Shapiro-Wilk (Statistic)	0.94*	0.90*	0.87*	0.93*	0.92*
Lilliefors (Statistic)	0.06*	0.10*	0.11*	0.08*	0.08*
Jarque-Bera (Statistic)	7426.56*	13629.84*	30072.55*	7165.04*	9526.83*
Kolmogorov-Smirnova (Statistic)**	0.06*	0.10*	0.11*	0.08*	0.08*
Statistic	**Hang Seng**	**Shanghai SE Composite**	**Nikkei 225**	**CAC All Share**	**Bombay Sensex**
Minimum	-6.02%	-8.87%	-11.15%	-12.42%	-14.10%
Maximum	5.52%	5.60%	7.73%	10.84%	8.59%
Median	0.06%	0.04%	0.07%	0.06%	0.06%
Mean	0.01%	0.00%	0.04%	0.02%	0.04%
Standard deviation (For population)	1.17%	1.35%	1.34%	1.21%	1.12%
Risk-adjusted returns	0.63%	0.19%	2.63%	1.57%	3.29%
Skewness (Pearson)	-0.33	-0.93	-0.46	-0.39	-0.85
Kurtosis (Pearson)	2.43	6.21	5.49	10.78	15.79
Shapiro-Wilk (Statistic)	0.97*	0.91*	0.95*	0.91*	0.90*
Lilliefors (Statistic)	0.06*	0.09*	0.07*	0.09*	0.07*
Jarque-Bera (Statistic)	711.38*	4727.17*	3455.03*	13186.34*	28498.30*
Kolmogorov-Smirnova (Statistic)**	0.06*	0.09*	0.07*	0.08*	0.07*

Note 1: Daily log-returns were evaluated.
Note 2: For the Nikkei 225 index data were only available from September 2010.
Note 3: Risk-adjusted returns were estimated by dividing the mean with the standard deviation.
* Signifies a p-value of 0.00, implying that H_0 is rejected for a normal distribution.
** The Lilliefors significance correction was applied.
Source: Data sourced from Infront (2022) and estimations done with XLSTAT (2014) software.

Vol: 14 **No:** 02 **Year:** 2022 **ISSN**: 1309-8055 (Online) (**pp.** 686-730) **Doi:** 10.34109/ijefs. 20220059

Table 2 Ratios and Variables Under Evaluation

FINANCIAL RATIOS		RISK-ADJUSTED PERFORMANCE RATIOS	
Ratio	**Source**	**Ratio**	**Source**
Assets / Capital Employed	(Ifeacho et al., 2014)	Burke	(Burke, 1994)
Cash Flow / Total Debt	(Jooste, 2007)	Calmar	(Young, 1991)
Current Ratio	(Uluyol et al., 2013)	CVaR-Sharpe[#]	(Esfahanipour et al., 2011)
Debt / Assets	(Detthamrong et al., 2017)	Israelson's Modified Sharpe	(Israelsen, 2005)
Debt / Equity	(Dita et al., 2014)	Kappa 3	(P. D. Kaplan et al., 2004)
Directors Remuneration Profit Before Tax (DRPBT)	(Kirsten et al., 2018)	Martin	(Martin et al., 1992)
Dividend Yield (DY)	(Lewellen, 2004)	MVaR-Sharpe[#]	(Gregoriou et al., 2003)
Earnings / Share	(Chang et al., 2008)	Omega	(Keating et al., 2002)
Earnings / Share Price	(Öztürk et al., 2018)	Omega-Sharpe	(Bacon, 2008)
Earnings Yield (EY)	(Tudor, 2010)	Pain	(Associates, 2006)
Inflation-adjusted Profit / Share Price	(Anandarajan et al., 2006; Bublitz et al., 1985; Kirkulak et al., 2009; Salaudeen, 2016)	Pezier's Adjusted Sharpe	(Pézier et al., 2006)
Inflation-adjusted Return on Assets (ROA)		Serial correlation (SC)-adjusted Sharpe	(Lo, 2002)
Inflation-adjusted Return on Average Equity (ROAE)		Scaled Sharpe (S*)	(Gatfaoui, 2008)
Inflation-adjusted Return on Average Total Assets (ROATA)		Scaled Sharpe (S**)	
Inflation-adjusted Return on Equity (ROE)		Scaled Treynor (T*)	
Price / Book Value	(Kheradyar et al., 2011)	Scaled Treynor (T**)	
Price / Cash-flow	(Cakici et al., 2017)	Sortino	(F. A. Sortino et al., 1991)
Price / Earnings (P/E)	(Weigand et al., 2007)	Sterling	(Bacon, 2008; Kolbadi et al., 2011)
Price / EBIT**	(Bouwens et al., 2019; Nissim, 2019)	Sterling-Calmar	(Bacon, 2008)
Price / EBITDA**		Jensen's Alpha	(Jensen, 1968)
Price / NAV	(Liow et al., 2018)	Traditional Sharpe	(Sharpe, 1966)
Quick Ratio	(Khaldun et al., 2014)	Traditional Treynor	(Treynor, 1965)
Return On Assets (ROA)	(Dadrasmoghadam et al., 2015)	Upside Potential	(F. Sortino et al., 1999)
Return On Capital Employed (ROCE)	(Jermsittiparsert et al., 2019)	VaR-Sharpe[#]	(Dowd, 1999, 2000)
Return On Equity (ROE)	(Petcharabul et al., 2014)	FINANCIAL VARIABLES (trading statistics)	
		Variable	**Source**
		Market Capitalisation	(Sanjoy, 1983)
		Trading Volume	(Naik et al., 2018)

Note: Refer to van Heerden (2020) for more detail on the risk-adjusted performance ratios.
** EBIT denotes earnings before interest and taxes and EBITDA denotes earnings before interest, taxes, depreciation, and amortisation.

Vol: 14 **No: 0**2 **Year:** 2022 **ISSN**: 1309-8055 (Online) (**pp.** 686-730) **Doi:** 10.34109/ijefs. 20220059

VaR denotes value-at-risk, where CVaR denotes the conditional VaR and MVaR denotes the modified VaR.
Source: Compiled by Author

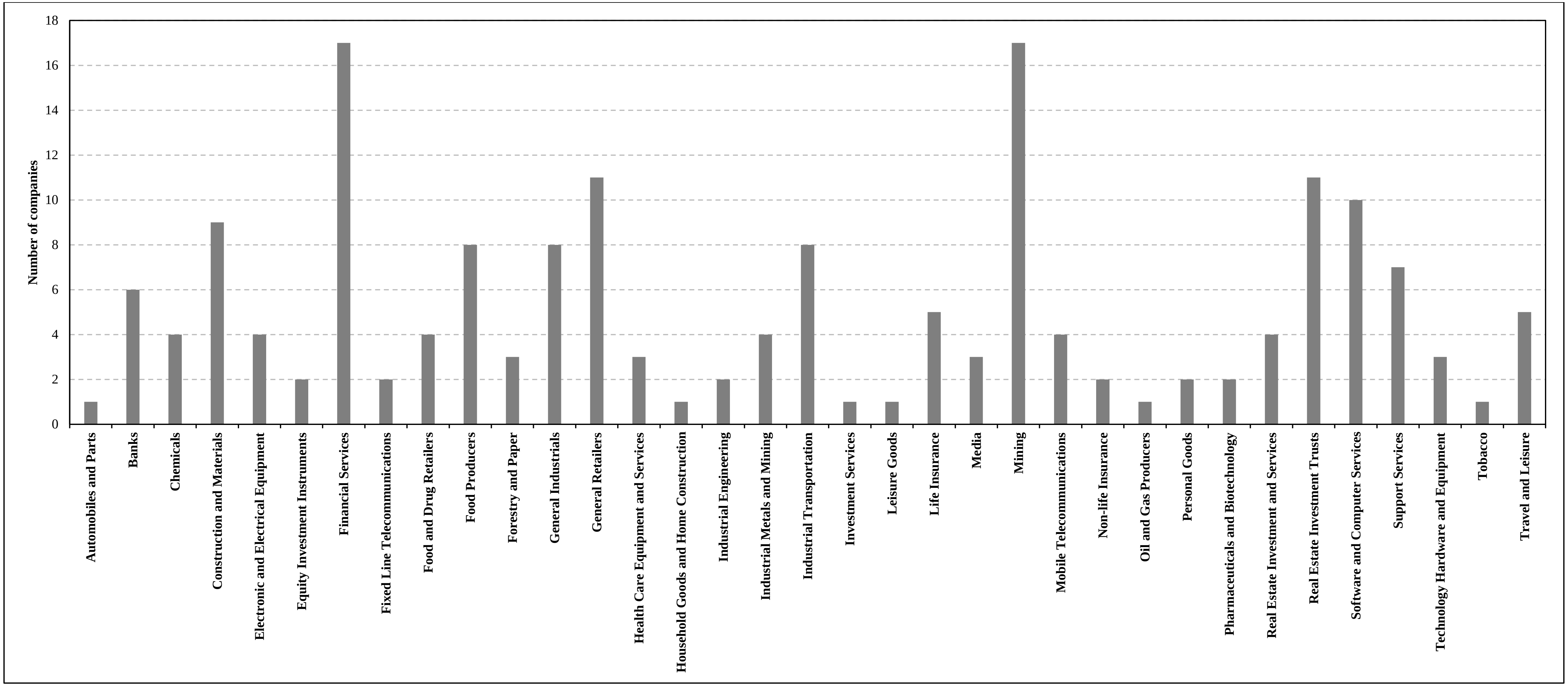

Figure 2: Sector Distribution of the 176 Selected Companies Under Evaluation
Source: Compiled by Author

Vol: 14 **No:** 02 **Year:** 2022 **ISSN**: 1309-8055 (Online) (**pp.** 686-730) **Doi:** 10.34109/ijefs. 20220059

The yearly financial ratio estimates and monthly share price data were sourced from IRESS (2022). The share price data were converted to returns, using natural logs and utilised to estimate the risk-adjusted performance ratios. Moreover, the effects of transaction costs and taxes were ignored. The selection of risk-adjusted performance ratios was based on the study of van Heerden (2020) and estimated with Microsoft® Excel. The JSE All Share index (J203) was used as the market proxy, whereas the 3-month negotiable certificate of deposit (NCD) rate was used as the risk-free rate proxy (Van Heerden, 2016). Monthly data for the market proxy and risk-free rate proxy were sourced from IRESS (2022) and Bank) (2022), respectively.

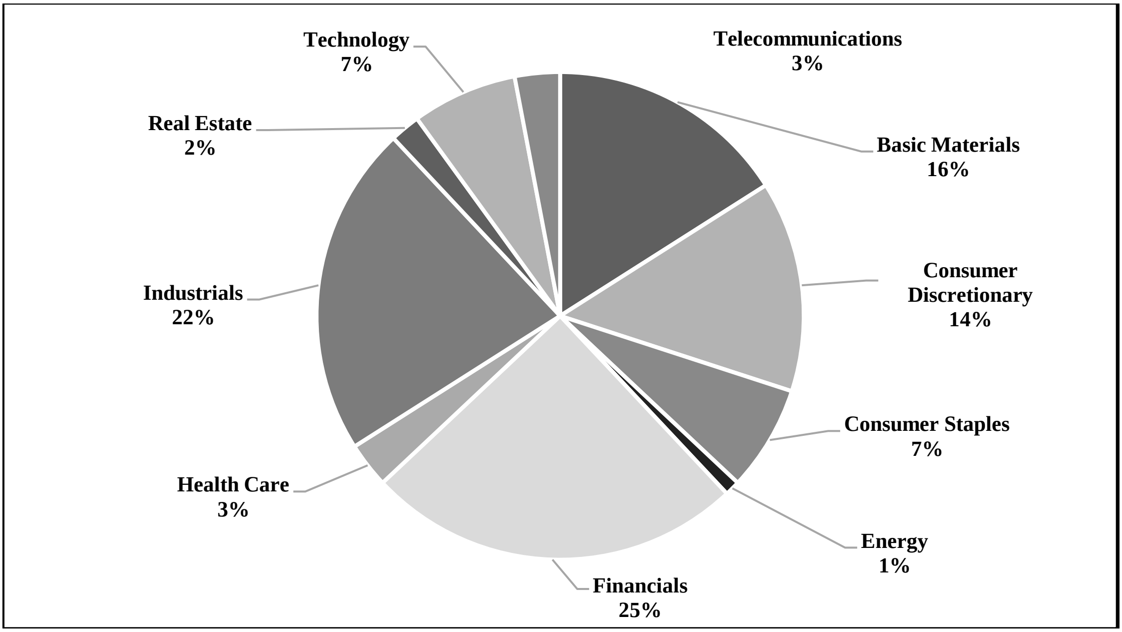

Figure 3: Industry Distribution of the 176 Selected Companies under Evaluation
Note: Composition based on the new Industry Classification Benchmark (ICB), as provided by FTSE Russell (2021).
Source: Compiled by Author

Due to the inability of the DEA model to accommodate non-positive observations, the scale of every series was adjusted accordingly. This will have no effect on the ratio comparison study, as the multi-stage DEA model will be executed for each ratio individually. Furthermore, the input-orientated approach was adopted, which according to operational research, characterises the production technology of the organisation for producing a given output mix with the minimum inputs (Coelli, 1998). Implying that the ratio or variable with the lowest estimates will be considered as the best in explaining share returns. Consequently, the inverse of some ratios and variables were used as inputs to ensure the accurate interpretation of the efficiency scores, where the latter will range between 0 and 1 (1 implies an 100% efficiency or ability to explain the 1-, 3-, and 5-years in-sample, ex post future realised share returns, respectively).

Vol: 14 **No: 0**2 **Year:** 2022 **ISSN**: 1309-8055 (Online) (**pp.** 686-730) **Doi:** 10.34109/ijefs. 20220059

5. RESULTS

Table 3 reports the overall ability (average efficiency) of each ratio and variable to explain 1-,

3-, and 5-years in-sample, ex post future realised share returns, respectively. At first glance the efficiency scores provide an explanation to why the literature has proven so many ratios and variables as viable predictors of future share returns. Table 3 reports that the majority of the ratios and variables under consideration has a reasonable ability to explain 1-, 3-, and 5-years in-sample, ex post future realised share returns, respectively. The inconsistency in the efficiency of some ratios between the three output scenarios (1-, 3-, and 5-years investment horizon), as reported by Table 3 and the inconsistency of the ratios' ability to explain returns from different sectors (see Table 5) may however provide additional evidence for the presence of time-varying market efficiency in the South African market (Heymans et al., 2018).

Nevertheless, from Table 3 it is evident that 30 ratios exhibited a consolidated overall efficiency of 95% and higher across all three output scenarios, which will receive the focus for the remainder of this study (see Table 4). The motivation for considering a consolidated perspective is to establish the ideal set of ratios that can be utilised by both passive and active investor. Initially, an early indication signified the importance of eliminating the T* or T** ratio, as these ratios realised a 100% correlation in portfolio composition. Therefore, the T* ratio was considered for further investigation, implying that only the top 29 ratios will be considered for the remainder of this study. Furthermore, it is interesting to note that the earnings per share, price-to-cash-flow, inflation-adjusted profit-to-share price, market capitalisation (market cap), and trading volume performed the worst across all three output scenarios, exhibiting an overall average efficiency of less than 1%. Consequently, these poor performing ratios will be eliminated and will not be considered for the remainder of this study.

To provide additional insight into each of the 29 selected ratios' explanatory ability, the top three sectors whose returns could be best explained by these ratios are reported by Table 5. It is evident that the bank sector's 1- and 3-years ahead returns could be explained by 10 different ratios at a significant high efficiency level. These results also accentuate the results found by (Heymans et al., 2018). Furthermore, the non-life insurance sector's 1-, 3-, and 5-years ahead returns could be explained at a significant level by 21, 22 and 27 of the 29 selected ratios, respectively. Also, the 1-, and 5-years ahead returns of the food and drug retailers' sector could be explained at significant level by 11 and 6 of the 29 selected ratios, respectively. It is also worth noting that the technology hardware and equipment sector's 1-, 3-, and 5-years ahead share returns could be explained at a significant level by 10 and 11 of the 29 selected ratios, respectively.

Vol: 14 **No:** 02 **Year:** 2022 **ISSN**: 1309-8055 (Online) (**pp.** 686-730) **Doi:** 10.34109/ijefs. 20220059

Table 3. The Overall Average Efficiency Scores of All Ratios and Variables under Consideration

Explaining 1-year ahead share returns		Explaining 3-years ahead share returns		Explaining 5-years ahead share returns	
Overall average	**Overall average**	**Overall average**	**Overall average**	**Ratios and variables**	**Overall average**
Jensen's Alpha	99.98%	Jensen's Alpha	99.98%	S*	99.98%
Kappa 3	99.97%	T*	99.98%	Jensen's Alpha	99.98%
Burke	99.97%	T**	99.98%	T*	99.98%
Israelson's Modified Sharpe	99.97%	Kappa 3	99.97%	T**	99.98%
Martin	99.97%	Burke	99.97%	Kappa 3	99.97%
Traditional Sharpe	99.97%	Israelson's Modified Sharpe	99.97%	Burke	99.97%
Pain	99.96%	Martin	99.97%	Martin	99.97%
Pezier's Adjusted Sharpe	99.95%	Traditional Sharpe	99.97%	Israelson's Modified Sharpe	99.97%
Sterling	99.93%	Pain	99.96%	Traditional Sharpe	99.97%
Sterling-Calmar	99.93%	Pezier's Adjusted Sharpe	99.95%	Pain	99.96%
S*	99.93%	Sterling	99.93%	Calmar	99.96%
Calmar	99.91%	Sterling-Calmar	99.93%	Pezier's Adjusted Sharpe	99.95%
T*	99.85%	S*	99.93%	Sterling	99.94%
T**	99.85%	Calmar	99.91%	Sterling-Calmar	99.94%
VaR-Sharpe	99.79%	VaR-Sharpe	99.78%	VaR-Sharpe	99.79%
SC-adjusted Sharpe	99.76%	SC-adjusted Sharpe	99.76%	SC-adjusted Sharpe	99.77%
Omega	99.57%	DY	99.67%	Upside Potential	99.75%
Omega-Sharpe	99.56%	Omega	99.57%	DY	99.67%
ROA	99.53%	Omega-Sharpe	99.56%	Omega	99.58%
Price / Book Value	99.45%	ROA	99.54%	Omega-Sharpe	99.56%
Debt / Assets	99.35%	Assets / Capital Employed	99.48%	ROA	99.54%
Debt / Equity	99.33%	Price / Book Value	99.48%	Assets / Capital Employed	99.51%
CVaR-Sharpe	99.24%	Debt / Assets	99.35%	Price / Book Value	99.48%
Assets / Capital Employed	99.13%	Debt / Equity	99.33%	Inflation-adjusted ROAE	99.40%
Current	98.91%	CVaR-Sharpe	99.24%	Debt / Assets	99.34%
Quick	98.91%	Current	98.91%	Debt / Equity	99.33%
ROCE	98.31%	Quick	98.91%	CVaR-Sharpe	99.24%
Inflation-adjusted ROATA	98.13%	Inflation-adjusted ROAE	98.83%	Inflation-adjusted ROA	98.97%
DY	98.03%	ROCE	98.31%	Current	98.91%
Upside Potential	95.75%	Inflation-adjusted ROATA	98.14%	Quick	98.91%

Note: Complete Results are Available on Request
Source: Compiled by Author

Vol: 14 **No:** 02 **Year:** 2022 **ISSN**: 1309-8055 (Online) (**pp.** 686-730) **Doi:** 10.34109/ijefs. 20220059

Table 3. The Overall Average Efficiency Scores of All Ratios and Variables under Consideration (Continues)

Explaining 1-year ahead returns		Explaining 3-years ahead returns		Explaining 5-years ahead returns	
Ratios and variables	**Overall efficiency average**	**Ratios and variables**	**Overall efficiency average**	**Ratios and variables**	**Overall efficiency average**
DRPBT	94.95%	Upside Potential	95.75%	ROCE	98.32%
Price / NAV	94.57%	Price / NAV	95.16%	Inflation-adjusted ROATA	98.14%
ROE	94.48%	DRPBT	94.95%	S**	97.38%
Earnings Yield	94.23%	ROE	94.48%	Price / NAV	96.84%
P/E	92.22%	Earnings Yield	94.24%	DRPBT	96.08%
Price / EBITDA	89.63%	P/E	92.22%	Sortino	95.61%
Inflation-adjusted ROE	89.32%	Price / EBIT	89.67%	ROE	94.49%
Cash Flow / Total Debt	87.29%	Price / EBITDA	89.62%	Earnings Yield	94.24%
Inflation-adjusted ROA	85.63%	Inflation-adjusted ROE	89.32%	P/E	92.21%
Traditional Treynor	84.94%	Cash Flow / Total Debt	87.29%	Price / EBIT	89.69%
S**	84.63%	Inflation-adjusted ROA	85.64%	Price / EBITDA	89.64%
MVaR-Sharpe	83.24%	Traditional Treynor	84.94%	Inflation-adjusted ROE	89.32%
Price / EBIT	80.20%	S**	84.64%	Cash Flow / Total Debt	87.29%
Inflation-adjusted ROAE	79.70%	MVaR-Sharpe	83.23%	Traditional Treynor	84.94%
Sortino	69.68%	Earnings / Share Price	76.99%	MVaR-Sharpe	83.23%
Earnings / Share Price	60.08%	Earnings / Share	49.61%	Earnings / Share Price	76.96%
Earnings / Share	49.60%	Price / Cash-flow	47.20%	Earnings / Share	49.69%
Price / Cash-flow	47.19%	Inflation-adjusted Profit / Share Price	42.66%	Price / Cash-flow	47.22%
Inflation-adjusted Profit / Share Price	36.62%	Market Cap	0.07%	Inflation-adjusted Profit / Share Price	42.69%
Market Cap	0.06%	Sortino	0.07%	Market Cap	0.10%
Trading Volume	0.00%	Trading Volume	0.00%	Trading Volume	0.00%

Note: Complete Results are Available on Request
Source: Compiled by Author

From the ICB's perspective this implies that the financial industry could be explained by the majority of the 29 selected ratios over all three output scenarios (1-, 3-, and 5-years investment horizon), followed by the telecommunication and health care sector, respectively. Nevertheless, in order to establish which ratio or set of ratios can be considered as 'all-inclusive' and ideal for share selection, each portfolio that was derived from the 29 selected ratios were examined based on its: (1) ability to outperform the market if used in 1-, 3-, and 5-years momentum investment strategies, respectively; (2) portfolios' average risk-adjusted returns derived from the three different momentum investment strategies; and (3) the level of correlation between the top 10 shares that were selected for each portfolio, as derived from the 29 selected ratios, respectively.

Table 6 reports that the portfolio derived from the Calmar ratio exhibited a significant higher level of outperformance (relative to the market proxy) from a 3-year momentum investment strategy perspective, compared to the other 28 competing ratios. Implying that the remainder of the selected ratios will be ignored from a 3-year momentum investment strategy perspective (see also Table A1 to A3 in the Appendix for more detailed results). This can be justified by the 33% difference in the level of outperformance between the top two performing ratios (the Calmar ratio and Jensen's Alpha, respectively). However, Table 6 also reports performance clusters that were observed, where similar high outperformance levels were exhibited by the top nine and 13 ratios from a 1- and 5-years momentum investment strategy perspective, respectively. Implying that further investigation will be required to establish ratio dominance.

On the upside, the results reported by Table 6 enabled an additional preliminary elimination of poor performing ratios. The worse performing ratios exhibited *underperformance clusters*, implying that ratios exhibiting underperformance levels (relative to the market proxy) higher than 50% from a 1- and 5-years momentum investment strategy perspective, respectively were eliminated and will not be considered for further evaluation. This also further emphasised the notion to consider only the Calmar ratio from a 3-years momentum investment strategy perspective, as all the other competing ratios as reported by Table 6 also exhibited underperformance levels higher than 50%.

To further the process of ratio elimination, the average risk-adjusted returns of the different portfolios, derived from the ratios still under consideration, were compared (see Table 7). Based on the average risk-adjusted returns of the portfolios that were utilised in the 1-, and 5-years momentum investment strategies, it is evident that the Calmar ratio produced much more profitable portfolios compared to the other competing ratios. From a 1-year momentum investment strategy perspective, the Pain, Sterling and Sterling-Calmar ratios produced the closest performing portfolios to the Calmar ratio, whereas Kappa 3 and the Martin ratios were the closest performing ratios from a 5-years momentum investment strategy perspective.

Vol: 14 **No: 0**2 **Year:** 2022 **ISSN**: 1309-8055 (Online) (**pp.** 686-730) **Doi:** 10.34109/ijefs. 20220059

Table 4. Selected Ratios with the Highest Efficiency Scores

Financial ratios		**Risk-adjusted performance ratios**			
Assets / Capital Employed	Inflation-adjusted ROATA	Burke	Martin	SC-adjusted Sharpe	Sterling-Calmar
Current	Price / Book Value	CVaR-Sharpe	Omega	S*	Jensen's Alpha
Debt / Assets	Quick	VaR-Sharpe	Omega-Sharpe	T*	Traditional Sharpe
Debt / Equity	ROA	Israelson's Modified Sharpe	Pain	T**	Upside Potential
DY	ROCE	Kappa 3	Pezier's Adjusted Sharpe	Sterling	Calmar

Source: Compiled by Author

Table 5. The Three Sector Best Explained by Each Ratio: Per Momentum Investment Strategy

Over different investment horizons	**Assets / Capital Employed**	**Current**	**Debt / Assets**	**Debt / Equity**	**DY**
Explaining 1-year ahead share returns	Health Care Equipment and Services	Non-life Insurance	Non-life Insurance	Industrial Engineering	Non-life Insurance
	Food Producers	Equity Investment Instruments	Mining	Construction and Materials	Fixed Line Telecommunications
	Non-life Insurance	Mining	Support Services	Support Services	Real Estate Investment Trusts
Explaining 3-years ahead share returns	Health Care Equipment and Services	Non-life Insurance	Non-life Insurance	Industrial Engineering	Fixed Line Telecommunications
	Food Producers	Mining	Mining	Construction and Materials	Non-life Insurance
	Non-life Insurance	Media	Media	Support Services	Investment Services
Explaining 5-years ahead share returns	Health Care Equipment and Services	Non-life Insurance	Non-life Insurance	Industrial Engineering	Fixed Line Telecommunications
	Food Producers	Mining	Mining	Non-life Insurance	Non-life Insurance
	Non-life Insurance	Media	Media	Construction and Materials	Industrial Engineering
Over different investment horizons	**Inflation-adjusted ROATA**	**Price / Book Value**	**Quick**	**ROA**	**ROCE**
Explaining 1-year ahead share returns	Non-life Insurance	General Industrials	Non-life Insurance	Travel and Leisure	Non-life Insurance
	Travel and Leisure	Construction and Materials	Mining	Industrial Metals and Mining	Food and Drug Retailers
	Industrial Metals and Mining	General Retailers	Equity Investment Instruments	Automobiles and Parts	Industrial Transportation
Explaining 3-years ahead share returns	Non-life Insurance	General Industrials	Non-life Insurance	Travel and Leisure	Non-life Insurance
	Travel and Leisure	Construction and Materials	Mining	Industrial Metals and Mining	Industrial Transportation
	Industrial Metals and Mining	Non-life Insurance	Media	Automobiles and Parts	Food and Drug Retailers
Explaining 5-years ahead share returns	Non-life Insurance	General Industrials	Non-life Insurance	Travel and Leisure	Non-life Insurance
	Travel and Leisure	Non-life Insurance	Mining	Industrial Metals and Mining	Industrial Transportation

Vol: 14 **No: 0**2 **Year:** 2022 **ISSN**: 1309-8055 (Online) (**pp.** 686-730) **Doi:** 10.34109/ijefs. 20220059

	Industrial Metals and Mining	Construction and Materials	Media	Automobiles and Parts	Food and Drug Retailers
Over different investment horizons	**Burke**	**CVaR-Sharpe**	**VaR-Sharpe**	**Israelson's Modified Sharpe**	**Kappa 3**
Explaining 1-year ahead share returns	Technology Hardware and Equipment	Non-life Insurance	Travel and Leisure	Technology Hardware and Equipment	Technology Hardware and Equipment
	Banks	Industrial Transportation	Non-life Insurance	Fixed Line Telecommunications	Non-life Insurance
	Food and Drug Retailers	Automobiles and Parts	Media	Automobiles and Parts	Banks
Explaining 3-years ahead share returns	Banks	Non-life Insurance	Non-life Insurance	Technology Hardware and Equipment	Technology Hardware and Equipment
	Technology Hardware and Equipment	Industrial Transportation	Travel and Leisure	Fixed Line Telecommunications	Banks
	Life Insurance	Automobiles and Parts	Pharmaceuticals and Biotechnology	Automobiles and Parts	Non-life Insurance
Explaining 5-years ahead share returns	Technology Hardware and Equipment	Non-life Insurance	Travel and Leisure	Fixed Line Telecommunications	Non-life Insurance
	Health Care Equipment and Services	Industrial Transportation	Non-life Insurance	Technology Hardware and Equipment	Technology Hardware and Equipment
	Life Insurance	Automobiles and Parts	Forestry and Paper	Non-life Insurance	Fixed Line Telecommunications

Source: Compiled by Author

Table 5. The Three Sector Best Explained by Each Ratio: Per Momentum Investment Strategy (Continues)

Over different investment horizons	Martin	Omega	Omega-Sharpe	Pain	Pezier's Adjusted Sharpe
Explaining 1-year ahead share returns	Technology Hardware and Equipment	Non-life Insurance	Non-life Insurance	Non-life Insurance	Technology Hardware and Equipment
	Banks	Food and Drug Retailers	Fixed Line Telecommunications	Technology Hardware and Equipment	Non-life Insurance
	Food and Drug Retailers	Life Insurance	Food and Drug Retailers	Banks	Banks
Explaining 3-years ahead share returns	Technology Hardware and Equipment	Non-life Insurance	Non-life Insurance	Non-life Insurance	Technology Hardware and Equipment
	Banks	Food and Drug Retailers	Fixed Line Telecommunications	Banks	Banks
	Life Insurance	Life Insurance	Food and Drug Retailers	Technology Hardware and Equipment	Non-life Insurance

Explaining 5-years ahead share returns	Technology Hardware and Equipment	Non-life Insurance	Non-life Insurance	Non-life Insurance	Technology Hardware and Equipment
	Health Care Equipment and Services	Life Insurance	Fixed Line Telecommunications	Technology Hardware and Equipment	Non-life Insurance
	Banks	Technology Hardware and Equipment	Life Insurance	Health Care Equipment and Services	Fixed Line Telecommunications
Over different investment horizons	**SC-adjusted Sharpe**	**S***	**T***	**T****	**Sterling**
Explaining 1-year ahead share returns	Fixed Line Telecommunications	Non-life Insurance	Non-life Insurance	Non-life Insurance	Technology Hardware and Equipment
	Tobacco	Media	Life Insurance	Life Insurance	Banks
	Non-life Insurance	Tobacco	Food and Drug Retailers	Food and Drug Retailers	Food and Drug Retailers
Explaining 3-years ahead share returns	Fixed Line Telecommunications	Non-life Insurance	Non-life Insurance	Non-life Insurance	Banks
	Non-life Insurance	Food Producers	Food and Drug Retailers	Food and Drug Retailers	Food and Drug Retailers
	Technology Hardware and Equipment	Leisure Goods	Construction and Materials	Construction and Materials	Technology Hardware and Equipment
Explaining 5-years ahead share returns	Fixed Line Telecommunications	Non-life Insurance	Non-life Insurance	Non-life Insurance	Health Care Equipment and Services
	Non-life Insurance	Leisure Goods	Construction and Materials	Construction and Materials	Technology Hardware and Equipment
	Technology Hardware and Equipment	Investment Services	Investment Services	Investment Services	Non-life Insurance
Over different investment horizons	**Sterling-Calmar**	**Jensen's Alpha**	**Traditional Sharpe**	**Upside Potential**	**Calmar**
Explaining 1-year ahead share returns	Technology Hardware and Equipment	Non-life Insurance	Technology Hardware and Equipment	Non-life Insurance	Non-life Insurance
	Banks	Banks	Food and Drug Retailers	Food and Drug Retailers	Technology Hardware and Equipment
	Food and Drug Retailers	Automobiles and Parts	Banks	Banks	Tobacco
Explaining 3-years ahead share returns	Banks	Non-life Insurance	Technology Hardware and Equipment	Non-life Insurance	Non-life Insurance
	Food and Drug Retailers	Banks	Life Insurance	Food and Drug Retailers	Food and Drug Retailers
	Technology Hardware and Equipment	Automobiles and Parts	Banks	Banks	Tobacco

Explaining 5-years ahead share returns	Health Care Equipment and Services	Non-life Insurance	Technology Hardware and Equipment	Non-life Insurance	Real Estate Investment and Services
	Technology Hardware and Equipment	Oil and Gas Producers	Non-life Insurance	Life Insurance	Tobacco
	Non-life Insurance	Automobiles and Parts	Tobacco	Banks	Non-life Insurance

Source: Compiled by Author

Table 6. The Level of Out- and Underperformance of Each Portfolio Derived from the Ratios Relative to the Market

1-year momentum investment strategy			**3-years momentum investment strategy**			**5-years momentum investment strategy**		
Portfolios based on these ratios	**Outperform**	**Underperform**	**Portfolios based on these ratios**	**Outperform**	**Underperform**	**Portfolios based on these ratios**	**Outperform**	**Underperform**
Jensen's Alpha	64%	36%	Calmar	89%	11%	Calmar	86%	14%
Israelson's Modified Sharpe	64%	36%	*Jensen's Alpha*	*56%*	*44%*	Jensen's Alpha	71%	29%
Pain	64%	36%	*Kappa 3*	*56%*	*44%*	Kappa 3	71%	29%
Sterling	64%	36%	*Burke*	*56%*	*44%*	Burke	71%	29%
Sterling-Calmar	64%	36%	*Israelson's Modified Sharpe*	*56%*	*44%*	Martin	71%	29%
Calmar	64%	36%	*Martin*	*56%*	*44%*	Traditional Sharpe	71%	29%
Omega	64%	36%	*Traditional Sharpe*	*56%*	*44%*	Pezier's Adjusted Sharpe	71%	29%
Omega-Sharpe	64%	36%	*Pain*	*56%*	*44%*	Sterling	71%	29%
Price / Book Value	64%	36%	*Pezier's Adjusted Sharpe*	*56%*	*44%*	Sterling-Calmar	71%	29%
Kappa 3	*55%*	*45%*	*Sterling*	*56%*	*44%*	Omega	71%	29%
Burke	*55%*	*45%*	*Sterling-Calmar*	*56%*	*44%*	Omega-Sharpe	71%	29%
Martin	*55%*	*45%*	*CVaR-Sharpe*	*56%*	*44%*	Upside Potential	71%	29%
Traditional Sharpe	*55%*	*45%*	*SC-adjusted Sharpe*	*56%*	*44%*	Price / Book Value	71%	29%
Pezier's Adjusted Sharpe	*55%*	*45%*	Omega	56%	44%	Israelson's Modified Sharpe	57%	43%
CVaR-Sharpe	*55%*	*45%*	Omega-Sharpe	56%	44%	Pain	57%	43%
SC-adjusted Sharpe	*55%*	*45%*	Upside Potential	56%	44%	CVaR-Sharpe	57%	43%
Upside Potential	*55%*	*45%*	Price / Book Value	56%	44%	SC-adjusted Sharpe	57%	43%
ROCE	*45%*	*55%*	VaR-Sharpe	56%	44%	VaR-Sharpe	43%	57%
*S**	*36%*	*64%*	ROA	44%	56%	*Inflation-adjusted ROATA*	*29%*	*71%*

Vol: 14 **No:** 02 **Year:** 2022 **ISSN**: 1309-8055 (Online) (**pp.** 686-730) **Doi:** 10.34109/ijefs. 20220059

ROA	*36%*	*64%*	T*	33%	67%	*T**	*14%*	*86%*
Debt / Assets	*36%*	*64%*	Inflation-adjusted ROATA	33%	67%	*ROA*	*14%*	*86%*
Inflation-adjusted ROATA	*36%*	*64%*	ROCE	22%	78%	*ROCE*	*14%*	*86%*
*T**	*27%*	*73%*	*Assets / Capital Employed*	*11%*	*89%*	*S**	*0%*	*100%*
Assets / Capital Employed	*27%*	*73%*	*Debt / Assets*	*11%*	*89%*	*Assets / Capital Employed*	*0%*	*100%*
Debt / Equity	*27%*	*73%*	*Debt / Equity*	*11%*	*89%*	*Debt / Assets*	*0%*	*100%*
DY	*27%*	*73%*	*Current*	*11%*	*89%*	*Debt / Equity*	*0%*	*100%*
VaR-Sharpe	*27%*	*73%*	*S**	*0%*	*100%*	*Current*	*0%*	*100%*
Current	*9%*	*91%*	*Quick*	*0%*	*100%*	*Quick*	*0%*	*100%*
Quick	*9%*	*91%*	*DY*	*0%*	*100%*	*DY*	*0%*	*100%*

Note 1: The bold line and italic formatting represent the underperformance clusters of worse performing ratios that were preliminary eliminated.
Note 2: More detailed results are available in Table A1 to A3 in the Appendix.
Source: Compiled by Author

Vol: 14 **No: 0**2 **Year:** 2022 **ISSN**: 1309-8055 (Online) (**pp.** 686-730) **Doi:** 10.34109/ijefs. 20220059

However, based on the literature ratios may exhibit overlapping information, implying that ratio rankings may suggest portfolio compositions with high correlation (Eling et al., 2007). To overcome this obstacle Table 8 and 9 report the correlation matrices of the portfolios that were derived from the top performing ratios, from a 1-, and 5-years momentum investment strategy perspective, respectively [Remember that the Calmar ratio exhibited significant dominance from a 3-year momentum investment strategy perspective (see Table 6), thus no further investigation will be required for the 3-year momentum investment strategy perspective].

Table 7. Average Risk-Adjusted Returns of Portfolios Derived from the Top Performing Ratios

1-year momentum investment strategy		5-years momentum investment strategy	
Calmar	12.50%	Calmar	11.72%
Pain	10.61%	Kappa 3	9.59%
Sterling	10.27%	Martin	9.28%
Sterling-Calmar	10.27%	Upside Potential	8.93%
Israelson's Modified Sharpe	9.96%	Jensen's Alpha	8.76%
Jensen's Alpha	7.18%	Burke	8.48%
Omega-Sharpe	6.83%	Sterling	8.45%
Omega	6.83%	Sterling-Calmar	8.45%
Price / Book Value	4.24%	Pezier's Adjusted Sharpe	8.41%
		Traditional Sharpe	7.85%
		Omega	7.53%
		Omega-Sharpe	7.53%
		Price / Book Value	5.39%

Note 1: Risk-adjusted returns were calculated by dividing the average returns with the standard deviation.
Note 2: Remember that each portfolio was evaluated over several years, explaining the use of risk-adjusted return averages.
Source: Compiled by Author

From the results reported by Table 8 there is a 100% correlation between the portfolios derived from the Omega-Sharpe and the Omega ratio, and between the Sterling and Sterling-Calmar ratios, respectively. Nevertheless, based on the results from Table 7 and 8 if would be advisable to consider only the Calmar ratio, or the Calmar with the price-to-book ratios, or a combination of the Pain and Omega ratios as an alternative to the Calmar ratio. In either case, these ratios have produced portfolios with a greater ability to outperform the market compared to other competing ratios from a 1-year momentum investment strategy perspective. Also, these portfolios exhibited some of the highest

Vol: 14 **No: 0**2 **Year:** 2022 **ISSN**: 1309-8055 (Online) (**pp.** 686-730) **Doi:** 10.34109/ijefs. 20220059

average portfolio risk-adjusted returns and the lowest portfolio correlation, where the latter implies greater portfolio diversification.

Additionally, from a 5-years momentum investment strategy perspective only the Calmar ratio can be considered. Alternatively, Table 9 reports low correlation between the portfolios derived from the Calmar and Upside Potential ratio, which may be considered as an alternative to boost portfolio performance and portfolio diversification. Lastly, Table 7 and 9 also report an alternative selection of the Kappa 3 and Upside Potential ratio, where their portfolios also produced low correlation and relatively high risk-adjusted returns from a 5-years momentum investment strategy perspective. Overall, besides for these alternatives, the results emphasised the Calmar ratio as the most ideal ratio to explain 1-, 3-, and 5-years ahead share returns. This ratio also exhibited the ability to produce portfolio selections that realised the highest risk-adjusted returns and greatest ability to outperform the market from all momentum investment strategy perspectives under evaluation.

6. CONCLUSION AND RECOMMENDATIONS

With the literature providing no guidance in terms of the methodology to adapt to identify the most ideal set of ratios for future share selections, provided the motivation for this endeavour. This study was the first to prove that the multi-stage DEA model can be considered as a successful ratio selecting tool, as it can acknowledge interdimensional relationships between ratios and share returns and uncover relationships that are unknown to other methodologies. By utilising the efficiency scores generated by the DEA model, permitted a ratio elimination process, through which 29 ratios were identified that exhibited the highest consolidation ability to explain both 1-, 3-, and 5-years in-sample, ex post future realised share returns. To identify the superior ratio, the equally weighted portfolios derived from each of the 29 selected ratios were evaluated according to their: (1) ability to outperform the market from a momentum investment strategy perspective; (2) to generate the highest risk-adjusted returns; and (3) exhibited the lowest portfolio composition correlation compared to portfolios derived from other competing ratios. The results emphasised the dominance of the Calmar ratio to explain both 1-, 3-, and 5 years in-sample, ex post future realised share returns. The Calmar ratio exhibited the ability to produce portfolio selections that realised the highest average risk-adjusted returns and greatest ability to outperform the market from all three momentum investment strategy perspectives under evaluation. However, alternative ratio combinations were also identified from a 1-year momentum investment strategy perspective, which included the Calmar with the price-to-book ratios, or a combination of the Pain and Omega ratios. Moreover, from 5-year momentum investment strategy perspective alternatives ratio combinations besides the Calmar ratio included the Kappa 3 and Upside Potential ratio.

Table 8. Correlation Between Portfolios Derived from Each of The Top Performing Ratios: For A 1-Year Momentum Investment Strategy

	Israelson's Modified Sharpe	Omega	Omega-Sharpe	Pain	Sterling	Sterling-Calmar	Jensen's Alpha	Calmar
Price / Book Value	0%	10%	10%	10%	0%	0%	20%	10%
Israelson's Modified Sharpe		70%	70%	40%	70%	70%	20%	50%
Omega			100%	30%	50%	50%	30%	40%
Omega-Sharpe				30%	50%	50%	30%	40%
Pain					60%	60%	30%	40%
Sterling						100%	20%	50%
Sterling-Calmar							20%	50%
Jensen's Alpha								40%

Source: Compiled by Author

Table 9. Correlation Between Portfolios Derived from Each of The Top Performing Ratios: For A 5-Years Momentum Investment Strategy

	Burke	Kappa 3	Martin	Omega	Omega-Sharpe	Pezier's Adjusted Sharpe	Sterling	Sterling-Calmar	Jensen's Alpha	Traditional Sharpe	Upside Potential	Calmar
Price / Book Value	10%	30%	10%	10%	10%	20%	10%	10%	30%	10%	10%	20%
Burke		60%	70%	40%	40%	70%	90%	90%	40%	90%	10%	60%
Kappa 3			50%	50%	50%	80%	60%	60%	60%	70%	10%	60%
Martin				30%	40%	50%	80%	80%	40%	60%	10%	50%
Omega					90%	50%	40%	40%	30%	40%	30%	40%
Omega-Sharpe						50%	50%	50%	30%	40%	30%	40%
Pezier's Adjusted Sharpe							70%	70%	50%	80%	10%	70%
Sterling								100%	40%	80%	10%	50%
Sterling-Calmar									40%	80%	10%	50%
Jensen's Alpha										40%	30%	40%
Traditional Sharpe											0%	70%
Upside Potential												10%

Source: Compiled by Author

To conclude, the implication of these results emphasises that the multi-stage DEA model can be considered as a viable tool to identify the ideal ratio for future share selections that will lead to market-outperforming portfolios. The simplicity of the DEA model makes it attractive for academicians and practitioners to apply to any market type or data set. Also, the evidence substantiates the argument that it is possible for both active and passive investors to utilise the same ratio or set of ratios to obtain profitable portfolios. However, preliminary results verified the notion that different ratio compositions in conjunction with the Calmar ratio must be used for different sectors and industries. This inconsistency in outperforming ratio compositions per sector/industry verifies the notion that the South African market is time-varying efficient and that the level of efficiency also varies across different sectors and industries (Heymans et al., 2018). The implication is that these findings violate the modern portfolio theory assumption of an efficient market, implying that market-outperforming decisions are possible. This emphasises the importance of consulting the level of market efficiency as an asset selection tool and a method to improve portfolio performance and diversification. It is suggested that future studies should further verify and investigate the extent of this notion.

Additionally, for future studies, it will be interesting to establish if the same array of 29 ratios will be dominate in crisis events and how the composition of top performing ratios will change from a pre- to a post-financial crisis period. The inability to completely explain share returns of industries or sectors and the inconsistency in the ability to explain share returns may also suggest the presence of time-varying market efficiency. Future studies can establish if ratios' explanatory ability will move in conjunction with time-varying market efficiency. Also, ratio selection may be dependable on asset characteristics, a theory worth investigating.

REFERENCES

Abad, C., Thore, S. A., & Laffarga, J. (2004). Fundamental analysis of stocks by two-stage DEA. *Managerial and Decision Economics*, *25*(5), 231-241. doi: https://doi.org/10.1002/mde.1145

Aigner, D., Lovell, C. K., & Schmidt, P. (1977). Formulation and estimation of stochastic frontier production function models. *Journal of Econometrics*, *6*(1), 21-37. doi: https://doi.org/10.1016/0304-4076(77)90052-5

Ames, D., Brazel, J. F., Jones, K. L., Rich, J. S., & Zimbelman, M. F. (2012). Using nonfinancial measures to improve fraud risk assessments. *Current Issues in Auditing*, *6*(1), C28-C34. doi: https://doi.org/10.2308/ciia-50168

Amin, G. R., & Hajjami, M. (2021). Improving DEA cross-efficiency optimization in portfolio selection. *Expert Systems with Applications*, *168*, 114280. doi: https://doi.org/10.1016/j.eswa.2020.114280

Anandarajan, A., Hasan, I., Isik, I., & McCarthy, C. (2006). The role of earnings and book values in pricing stocks: evidence from Turkey. *Advances in International Accounting, 19*, 59-89. doi: https://doi.org/10.1016/S0897-3660(06)19003-0

Araújo, R. C. d. C., & Machado, M. A. V. (2018). Book-to-market ratio, return on equity and Brazilian stock returns. *RAUSP Management Journal, 53*, 324-344. doi: https://doi.org/10.1108/RAUSP-04-2018-001

Asness, C. S., Porter, R. B., & Stevens, R. L. (2000). Predicting stock returns using industry-relative firm characteristics. *Available at SSRN 213872*, 46. doi: https://dx.doi.org/10.2139/ssrn.213872

Associates, Z. (2006). Pain ratio. Retrieved from http://www.styleadvisor.com/content/pain-ratio

Auret, C., & Cline, R. (2011). Do the value, size and January effects exist on the JSE? *Investment Analysts Journal, 40*(74), 29-37. doi: https://doi.org/10.1080/10293523.2011.11082539

Auret, C., & Sinclaire, R. (2006). Book-to-market ratio and returns on the JSE. *Investment Analysts Journal, 35*(63), 31-38. doi: https://doi.org/10.1080/10293523.2006.11082476

Avkiran, N. K. (1997). Models of retail performance for bank branches: predicting the level of key business drivers. *International Journal of Bank Marketing, 15*(6), 224-237. doi: https://doi.org/10.1108/02652329710184451

Avkiran, N. K. (1999). An application reference for data envelopment analysis in branch banking: helping the novice researcher. *International Journal of Bank Marketing, 17*(5), 206-220. doi: https://doi.org/10.1108/02652329910292675

Bacon, C. R. (2008). *Practical portfolio performance measurement and attribution* (Vol. 546): John Wiley & Sons. Retrieved from https://books.google.ae/books?hl=en&lr=&id=BppfDwAAQBAJ&oi=fnd&pg=PR15&dq=Bacon

Balakrishnan, K., Bartov, E., & Faurel, L. (2010). Post loss/profit announcement drift. *Journal of Accounting and Economics, 50*(1), 20-41. doi: https://doi.org/10.1016/j.jacceco.2009.12.002

Ball, R., Gerakos, J., Linnainmaa, J. T., & Nikolaev, V. (2020). Earnings, retained earnings, and book-to-market in the cross section of expected returns. *Journal of Financial Economics, 135*(1), 231-254. doi: https://doi.org/10.1016/j.jfineco.2019.05.013

Bank), S. S. A. R. (2022). Date source. Retrieved from https://www.resbank.co.za/en/home/what-we-do/statistics/releases/online-statistical-query

Banker, R. D. (1993). Maximum likelihood, consistency and data envelopment analysis: a statistical foundation. *Management Science, 39*(10), 1265-1273. doi: https://doi.org/10.1287/mnsc.39.10.1265

Banker, R. D., Charnes, A., & Cooper, W. W. (1984). Some models for estimating technical and scale inefficiencies in data envelopment analysis. *Management Science*, *30*(9), 1078-1092. doi: https://doi.org/10.1287/mnsc.30.9.1078

Banz, R. W. (1981). The relationship between return and market value of common stocks. *Journal of Financial Economics*, *9*(1), 3-18. doi: https://doi.org/10.1016/0304-405X(81)90018-0

Barnes, P. (1987). The analysis and use of financial ratios. *Journal of Business Finance dan Accounting*, *14*(4), 449. Retrieved from https://www.superbessaywriters.com/wp-content/uploads/2016/12/week_5_discussion_1_information_0.pdf

Basiewicz, P., & Auret, C. (2010). Feasibility of the Fama and French three factor model in explaining returns on the JSE. *Investment Analysts Journal*, *39*(71), 13-25. doi: https://doi.org/10.1080/10293523.2010.11082516

Bekaert, G., Erb, C. B., Harvey, C. R., & Viskanta, T. E. (1998). Distributional characteristics of emerging market returns and asset allocation. *Journal of Portfolio Management*, *24*(2), 102-+. Retrieved from https://pages.stern.nyu.edu/~jmei/distributional.pdf

Berg, S. A., Førsund, F. R., & Jansen, E. S. (1991). Technical efficiency of Norwegian banks: The non-parametric approach to efficiency measurement. *Journal of Productivity Analysis*, *2*(2), 127-142. doi: https://doi.org/10.1007/BF00156343

Berzkalne, I., & Zelgalve, E. (2014). Return on equity and company characteristics: an empirical study of industries in Latvia. *The 8th International Days of Statistics and Economics*, *8*, 94-103. Retrieved from https://msed.vse.cz/msed_2014/article/253-Berzkalne-Irina-paper.pdf

Bhandari, L. C. (1988). Debt/equity ratio and expected common stock returns: Empirical evidence. *The Journal of Finance*, *43*(2), 507-528. doi: https://doi.org/10.1111/j.1540-6261.1988.tb03952.x

Black, F. (1972). Capital market equilibrium with restricted borrowing. *The Journal of Business*, *45*(3), 444-455. Retrieved from https://www.jstor.org/stable/2351499

Bouwens, J., De Kok, T., & Verriest, A. (2019). The prevalence and validity of EBITDA as a performance measure. *Comptabilite Controle Audit*, *25*(1), 55-105. Retrieved from https://www.cairn.info/revue-comptabilite-controle-audit-2019-1-page-55.htm?ref=doi

Bublitz, B., Frecka, T. J., & McKeown, J. C. (1985). Market association tests and FASB Statement No. 33 disclosures: A reexamination. *Journal of Accounting Research*, *23*, 1-23. doi: https://doi.org/10.2307/2490685

Burke, G. (1994). A sharper Sharpe ratio. *Futures*, *23*(3), 56. Retrieved from https://web-s-ebscohost-com.nwulib.nwu.ac.za/ehost/detail/detail?vid=4&sid=6cfb42e7-721c-412b-8860-202e8626e2f6%40redis&bdata=#AN=9411286739&db=f5h

Cakici, N., Chan, K., & Topyan, K. (2017). Cross-sectional stock return predictability in China. *The European Journal of Finance, 23*(7-9), 581-605. doi: https://doi.org/10.1080/1351847X.2014.997369

Chan, L. K., Hamao, Y., & Lakonishok, J. (1991). Fundamentals and stock returns in Japan. *The Journal of Finance, 46*(5), 1739-1764. doi: https://doi.org/10.1111/j.1540-6261.1991.tb04642.x

Chang, H.-L., Chen, Y.-S., Su, C.-W., & Chang, Y.-W. (2008). The relationship between stock price and EPS: Evidence based on Taiwan panel data. *Economics Bulletin, 3*(30), 1-12. Retrieved from https://tkuir.lib.tku.edu.tw/dspace/retrieve/153257

Charnes, A., Cooper, W. W., & Rhodes, E. (1978). Measuring the efficiency of decision making units. *European Journal of Operational Research, 2*(6), 429-444. doi: https://doi.org/10.1016/0377-2217(78)90138-8

Chen, K. H., & Shimerda, T. A. (1981). An empirical analysis of useful financial ratios. *Financial management, 10*(1), 51-60. doi: https://doi.org/10.2307/3665113

Clark, P. (1997). The balanced scorecard. *Accountancy Ireland, 29*(6), 25-26.

Coelli, T. (1998). A multi-stage methodology for the solution of orientated DEA models. *Operations Research Letters, 23*(3-5), 143-149. doi: https://doi.org/10.1016/S0167-6377(98)00036-4

Coelli, T., Rao, D. P., & Battese, G. (1998). An Introduction to Efficiency and Productivity Analysis", Kluwer Academic Publishers, Boston. In: DordrechtiLondon.

Cooper, W. W., Seiford, L. M., & Tone, K. (2007). *Data envelopment analysis: a comprehensive text with models, applications, references and DEA-solver software* (Vol. 2): Springer

Dadrasmoghadam, A., & Akbari, S. M. R. (2015). Relationship between financial ratios in the stock prices of agriculture-related companies accepted on the stock exchange for Iran. *Research Journal of Fisheries and Hydrobiology, 10*(9), 586-591. Retrieved from http://www.aensiweb.com/old/jasa/rjfh/2015/May/586-591.pdf

Davenport, T., & Sherman, H. (1987). Measuring branch profitability. *The Banker's Magazine, 170*(5), 37-38.

Detthamrong, U., Chancharat, N., & Vithessonthi, C. (2017). Corporate governance, capital structure and firm performance: Evidence from Thailand. *Research in International Business and Finance, 42*, 689-709. doi: https://doi.org/10.1016/j.ribaf.2017.07.011

Dita, A. H., & Murtaqi, I. (2014). The effect of net profit margin, price to book value and debt to equity ratio to stock return in the Indonesian consumer goods industry. *Journal of Business and Management, 3*(3), 305-315. Retrieved from http://download.garuda.kemdikbud.go.id/article.php?article=1529657&val=2218&title

Dowd, K. (1999). A value at risk approach to risk-return analysis. *The Journal of Portfolio Management, 25*(4), 60-67. Retrieved from https://jpm.pm-research.com/content/25/4/60.short

Dowd, K. (2000). Adjusting for risk:: An improved Sharpe ratio. *International Review of Economics & Finance, 9*(3), 209-222. doi: https://doi.org/10.1016/S1059-0560(00)00063-0

Eling, M., & Schuhmacher, F. (2007). Does the choice of performance measure influence the evaluation of hedge funds? *Journal of Banking & Finance, 31*(9), 2632-2647. doi: https://doi.org/10.1016/j.jbankfin.2006.09.015

Esfahanipour, A., & Mousavi, S. (2011). A genetic programming model to generate risk-adjusted technical trading rules in stock markets. *Expert Systems with Applications, 38*(7), 8438-8445. doi: https://doi.org/10.1016/j.eswa.2011.01.039

Fama, E. F., & French, K. R. (1992). The cross-section of expected stock returns. *The Journal of Finance, 47*(2), 427-465. doi: https://doi.org/10.1111/j.1540-6261.1992.tb04398.x

Fama, E. F., & French, K. R. (2017). International tests of a five-factor asset pricing model. *Journal of financial Economics, 123*(3), 441-463. doi: https://doi.org/10.1016/j.jfineco.2016.11.004

Fama, E. F., & French, K. R. (2018). Choosing factors. *Journal of Financial Economics, 128*(2), 234-252. doi: https://doi.org/10.1016/j.jfineco.2018.02.012

Farrell, M. J. (1957). The measurement of productive efficiency. *Journal of the Royal Statistical Society: Series A (General), 120*(3), 253-281. doi: https://doi.org/10.2307/2343100

Gadoiu, M. (2014). Advantages and limitations of the financial ratios used in the financial diagnosis of the enterprise. *Scientific Bulletin-Economic Sciences, 13*(2), 87-95. Retrieved from http://economic.upit.ro/repec/pdf/2014_2_9.pdf

Gatfaoui, H. (2008). *A correction for classic performance measures.* Paper presented at the 21st Australasian Finance and Banking Conference *11*(1), 1-28. doi: https://dx.doi.org/10.2139/ssrn.1237503

Golany, B., & Storbeck, J. E. (1999). A data envelopment analysis of the operational efficiency of bank branches. *Interfaces, 29*(3), 14-26. doi: https://doi.org/10.1287/inte.29.3.14

Gregoriou, G. N., & Gueyie, J.-P. (2003). Risk-adjusted performance of funds of hedge funds using a modified Sharpe ratio. *The Journal of Wealth Management, 6*(3), 77-83. doi: https://doi.org/10.3905/jwm.2003.442378

Gregoriou, G. N., Sedzro, K., & Zhu, J. (2005). Hedge fund performance appraisal using data envelopment analysis. *European Journal of Operational Research, 164*(2), 555-571. doi: https://doi.org/10.1016/j.ejor.2003.12.019

Grosskopf, S. (1996). Statistical inference and nonparametric efficiency: A selective survey. *Journal of Productivity Analysis, 7*(2), 161-176. doi: https://doi.org/10.1007/BF00157039

Haslem, J. A., & Scheraga, C. A. (2003). Data envelopment analysis of Morningstar's large-cap mutual funds. *The Journal of Investing, 12*(4), 41-48. doi: https://doi.org/10.3905/joi.2003.319566

Heymans, A., & Santana, L. (2018). How efficient is the Johannesburg Stock Exchange really? *South African Journal of Economic and Management Sciences, 21*(1), 1-14. Retrieved from https://hdl.handle.net/10520/EJC-1221a0a11e

Ho, C.-T. B., & Oh, K.-B. (2010). Selecting internet company stocks using a combined DEA and AHP approach. *International Journal of Systems Science, 41*(3), 325-336. doi: https://doi.org/10.1080/00207720903326902

Hoffman, A. (2012). Stock return anomalies: evidence from the Johannesburg Stock Exchange. *Investment Analysts Journal, 41*(75), 21-41. doi: https://doi.org/10.1080/10293523.2012.11082542

Hou, K., Karolyi, G. A., & Kho, B.-C. (2011). What factors drive global stock returns? *The Review of Financial Studies, 24*(8), 2527-2574. doi: https://doi.org/10.1093/rfs/hhr013

Ifeacho, C., & Ngalawa, H. (2014). Performance of the South African banking sector since 1994. *Journal of Applied Business Research (jabr), 30*(4), 1183-1196. doi: https://doi.org/10.19030/jabr.v30i4.8663

IRESS. (2022). Date source. Retrieved from http://secure.mcgbfa.com

Israelsen, C. L. (2005). A refinement to the Sharpe ratio and information ratio. *Journal of Asset Management, 5*(6), 423-427. doi: https://doi.org/10.1057/palgrave.jam.2240158

Jaforullah, M., & Whiteman, J. (1999). Scale efficiency in the New Zealand dairy industry: a non-parametric approach. *Australian Journal of Agricultural and Resource Economics, 43*(4), 523-541. doi: https://doi.org/10.1111/1467-8489.00093

Jensen, M. C. (1968). The performance of mutual funds in the period 1945-1964. *The Journal of Finance, 23*(2), 389-416. doi: https://doi.org/10.2307/2325404

Jermsittiparsert, K., Ambarita, D. E., Mihardjo, L. W., & Ghani, E. K. (2019). Risk-Return Through Financial Ratios as Determinants of Stock Price: A Study from Asean Region. *Journal of Security & Sustainability Issues, 9*(1), 1-12. doi: http://doi.org/10.9770/jssi.2019.9.1(15)

Johannes, M., Korteweg, A., & Polson, N. (2014). Sequential learning, predictability, and optimal portfolio returns. *The Journal of Finance, 69*(2), 611-644. doi: https://doi.org/10.1111/jofi.12121

Johnson, T. H., & Kaplan, R. S. (1987). Relevance lost: the rise and fall of management accounting. Retrieved from http://connections-qj.org/article/relevance-lost-rise-and-fall-management-accounting

Jooste, L. (2007). An evaluation of the usefulness of cash flow ratios to predict financial distress. *Acta Commercii, 7*(1), 1-13. doi: https://doi.org/10.4102/ac.v7i1.2

Kaplan, P. D., & Knowles, J. A. (2004). Kappa: A generalized downside risk-adjusted performance measure. *Journal of Performance Measurement.*, *8*, 42-54. Retrieved from http://ww.performance-measurement.org/KaplanKnowles2004.pdf

Kaplan, R. S., & Norton, D. P. (1996). Using the balanced scorecard as a strategic management system. In (Vol. 74, pp. 75-85): Harvard Business Review Boston. Retrieved from http://jackson.com.np/home/documents/MBA4/Management_accounting/BSC HarvardBusinessReview.pdf.

Keating, C., & Shadwick, W. F. (2002). A universal performance measure. *Journal of Performance Measurement*, *6*(3), 59-84. Retrieved from https://people.duke.edu/~charvey/Teaching/BA453_2004/Keating_A_universal _performance.pdf

Khaldun, K. I., & Muda, I. (2014). The Influence of Profitability and Liquidity Ratios on The Growth of Profit of Manufacturing Companies A Study of Food And Beverages Sector Companies Listed on Indonesia Stock Exchange (Period 2010-2012). *International Journal of Economics, Commerce and Management*, *2*(12), 1-17. Retrieved from http://citeseerx.ist.psu.edu/viewdoc/summary?doi=10.1.1.681.1020

Kheradyar, S., Ibrahim, I., & Nor, F. M. (2011). Stock return predictability with financial ratios. *International Journal of Trade, Economics and Finance*, *2*(5), 391. doi: https://doi.org/10.7763/IJTEF.2011.V2.137

Kirigia, J., Sambo, L. G., & Scheel, H. (2001). Technical efficiency of public clinics in Kwazulu-Natal province of South Africa. *East African Medical Journal*, *78*(3), 1-14. doi: https://doi.org/10.4314/eamj.v78i3.9070

Kirkulak, B., & Balsari, C. K. (2009). Value relevance of inflation-adjusted equity and income. *The International Journal of Accounting*, *44*(4), 363-377. doi: https://doi.org/10.1016/j.intacc.2009.09.007

Kirsten, E., & Du Toit, E. (2018). The relationship between remuneration and financial performance for companies listed on the Johannesburg Stock Exchange. *South African Journal of Economic and Management Sciences*, *21*(1), 1-10. Retrieved from https://hdl.handle.net/10520/EJC-e8d5e6c05

Kittelsen, S. A. (1999). *Monte Carlo simulations of DEA efficiency measures and hypothesis tests*. Retrieved from. Retrieved from https://www.econstor.eu/handle/10419/63113.

Kolbadi, P., & Ahmadinia, H. (2011). Examining Sharp, Sortino and Sterling ratios in portfolio management, evidence from Tehran stock exchange. *International Journal of Business and Management*, *6*(4), 222. doi: https://doi.org/10.5539/ijbm.v6n4p222

Kumar, N., & Singh, A. (2014). Efficiency analysis of banks using DEA: A review. *International Journal of Advance Research and Innovation*, *1*, 120-126.

Retrieved from https://www.researchgate.net/profile/Nand-Kumar/publication/261297255

Lakonishok, J., Shleifer, A., & Vishny, R. W. (1994). Contrarian investment, extrapolation, and risk. *The Journal of Finance*, *49*(5), 1541-1578. doi: https://doi.org/10.1111/j.1540-6261.1994.tb04772.x

Lewellen, J. (2004). Predicting returns with financial ratios. *Journal of Financial Economics*, *74*(2), 209-235. doi: https://doi.org/10.1016/j.jfineco.2002.11.002

Lintner, J. (1969). The valuation of risk assets and the selection of risky investments in stock portfolios and capital budgets: A reply. *The Review of Economics and Statistics*, *47*(1), 222-224. doi: https://doi.org/10.2307/1926735

Liow, K. H., & Yeo, S. (2018). Dynamic relationships between price and net asset value for Asian real estate stocks. *International Journal of Financial Studies*, *6*(1), 28. doi: https://doi.org/10.3390/ijfs6010028

Litzenberger, R. H., & Ramaswamy, K. (1979). The effect of personal taxes and dividends on capital asset prices: Theory and empirical evidence. *Journal of Financial Economics*, *7*(2), 163-195. doi: https://doi.org/10.1016/0304-405X(79)90012-6

Liu, J. S., Lu, L. Y., Lu, W.-M., & Lin, B. J. (2013). A survey of DEA applications. *Omega*, *41*(5), 893-902. doi: https://doi.org/10.1016/j.omega.2012.11.004

Lo, A. W. (2002). The statistics of Sharpe ratios. *Financial Analysts Journal*, *58*(4), 36-52. doi: https://doi.org/10.2469/faj.v58.n4.2453

Lovell, C. (1995). K, and Pastor, JT 1995." Units invariant and translation invariant DEA models.". *Oper. Res. Let*, *18*(3), 147-151. doi: https://doi.org/10.1016/0167-6377(95)00044-5

Markowitz, H. (1952). Selection Portfolio.“. *The Journal of Finance*, *7*(1), 77-91. doi: https://doi.org/10.1111/j.1540-6261.1952.tb01525.x

Martin, P., & McCann, B. (1992). The Investor‘s Guide to Fidelity Funds: Winning Strategies for Mutual Funds Investing. In: Venture Catalyst, Redmond, Washington.

McMillan, D. G. (2019). Predicting firm level stock returns: Implications for asset pricing and economic links. *The British Accounting Review*, *51*(4), 333-351. doi: https://doi.org/10.1016/j.bar.2019.04.001

Meeusen, W., & van Den Broeck, J. (1977). Efficiency estimation from Cobb-Douglas production functions with composed error. *International Economic Review*, *18*(2), 435-444. doi: https://doi.org/10.2307/2525757

Morey, M. R., & Morey, R. C. (1999). Mutual fund performance appraisals: a multi-horizon perspective with endogenous benchmarking. *Omega*, *27*(2), 241-258. doi: https://doi.org/10.1016/S0305-0483(98)00043-7

Mossin, J. (1966). Equilibrium in a capital asset market. *Econometrica: Journal of the Econometric Society*, *34*(4), 768-783. doi: https://doi.org/10.2307/1910098

Murthi, B., Choi, Y. K., & Desai, P. (1997). Efficiency of mutual funds and portfolio performance measurement: A non-parametric approach. *European Journal of Operational Research*, *98*(2), 408-418. doi: https://doi.org/10.1016/S0377-2217(96)00356-6

Naik, P. K., Gupta, R., & Padhi, P. (2018). The relationship between stock market volatility and trading volume: Evidence from South Africa. *The Journal of Developing Areas, 52*(1), 99-114. doi: https://doi.org/10.1353/jda.2018.0007

Nissim, D. (2019). EBITDA, EBITA, or EBIT? Columbia Business School Research Paper No. 17-71. In. Retrieved from https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2999675.

Nunamaker, T. R. (1985). Using data envelopment analysis to measure the efficiency of non-profit organizations: A critical evaluation. *Managerial and Decision Economics*, *6*(1), 50-58. doi: https://doi.org/10.1002/mde.4090060109

Ocran, M. K. (2010). South Africa and United States stock prices and the Rand/Dollar exchange rate. *South African Journal of Economic and Management Sciences, 13*(3), 362-375. Retrieved from http://www.scielo.org.za/scielo.php?script=sci_arttext&pid=S2222-34362010000300007

Öztürk, H., & Karabulut, T. A. (2018). The relationship between earnings-to-price, current ratio, profit margin and return: an empirical analysis on Istanbul stock exchange. *Accounting and Finance Research, 7*(1), 109-115. doi: https://doi.org/10.5430/afr.v7n1p

Pätäri, E. J., Leivo, T. H., & Samuli Honkapuro, J. V. (2010). Enhancement of value portfolio performance using data envelopment analysis. *Studies in Economics and Finance*, *27*(3), 223-246. doi: https://doi.org/10.1108/10867371011060036

Petcharabul, P., & Romprasert, S. (2014). Technology industry on financial ratios and stock returns. *Journal of Business and Economics, 5*(5), 739-746. Retrieved from http://www.academicstar.us/UploadFile/Picture/2014-6/201461451928720.pdf

Pézier, J., & White, A. (2006). *The relative merits of investable hedge fund indices and of funds of hedge funds in optimal passive portfolios*. Retrieved from. Retrieved from https://ideas.repec.org/p/rdg/icmadp/icma-dp2006-10.

Powers, J., & McMullen, P. (2000). Using data envelopment analysis to select efficient large market cap securities. *Journal of Business and Management*, *7*(2), 31-42. Retrieved from http://www.joydivisionman.com/vita/jbam2.pdf

Premachandra, I., Powell, J. G., & Shi, J. (1998). Measuring the relative efficiency of fund management strategies in New Zealand using a spreadsheet-based stochastic data envelopment analysis model. *Omega*, *26*(2), 319-331. doi: https://doi.org/10.1016/S0305-0483(98)00002-4

Reilly, F. K., Brown, K.C., Leeds, S, J. (2018). Investment analysis & portfolio management (11th ed.). Boston: Cengage.

Rensburg, P. v., & Robertson, M. (2003). Size, price-to-earnings and beta on the JSE Securities Exchange. *Investment Analysts Journal*, *32*(58), 7-16. doi: https://doi.org/10.1080/10293523.2003.11082449

Rosenberg, B., Reid, K., & Lanstein, R. (2021). Persuasive Evidence of Market Inefficiency (Spring 1985). In *Streetwise* (Vol. 11, pp. 48-55): Princeton University Press, 48-55. doi: https://doi.org/10.1515/9781400829408-00722totalcitationsonDimensions.

Ross, S. A., Westerfield, R., & Jordan, B. D. (2014). *Fundamentals of corporate finance*: Irwin New York, NY, USA. Retrieved from https://d1wqtxts1xzle7.cloudfront.net/56301542/ross6

Russell, F. (2021). ICB codes & descriptions. Retrieved from https://www.ftserussell.com/data/industry-classification-benchmark-icb

Salaudeen, Y. M. (2016). Value relevance of historical and inflation adjusted accounting information in Nigeria. KASU Journal of Accounting Research and Practice. *5*(2), 1-18. Retrieved from file:///C:/Users/12692174/Downloads/ValueRelevanceofAccountingInformationHistoricalCostversusInflationAdjusted.pdf

Sanjoy, B. (1983). The Relationship between Earnings' Yield, Market Value and Return for NYSE Common Stocks. *Journal of Financial Economics*, *12*(1), 129-156. doi: https://doi.org/10.1016/0304-405X(83)90031-4

Schwert, G. W. (2002). Anomalies and market efficiency. Working Paper 9277. Retrieved from https://www.nber.org/system/files/working_papers/w9277/w9277.pdf

Sengupta, J. K. (1989). Nonparametric tests of efficiency of portfolio investment. *Journal of Economics*, *50*(1), 1-15. Retrieved from https://www.jstor.org/stable/41793983

Sharma, K. R., Leung, P., & Zaleski, H. M. (1997). Productive efficiency of the swine industry in Hawaii: stochastic frontier vs. data envelopment analysis. *Journal of Productivity Analysis*, *8*(4), 447-459. doi: https://doi.org/10.1023/A:1007744327504

Sharpe, W. F. (1966). Mutual fund performance. *The Journal of Business*, *39*(1), 119-138. Retrieved from https://www.jstor.org/stable/2351741

Shephard, R. W. (2012). *Cost and production functions* (Vol. 194): Springer Science & Business Media. Retrieved from https://books.google.ae/books?hl=en&lr=&id=V6f7CAAAQBAJ&oi=fnd&pg=PA3&dq=Cost

Singleton-Green, B. (1993). If it matters, measure it! *Accountancy-London*, *111*, 52-53. Retrieved from https://web-s-ebscohost-com.nwulib.nwu.ac.za/ehost/detail/detail?vid=12&sid=6cfb42e7-721c-412b-8860-202e8626e2f6%40redis&bdata=#AN=5907157&db=aci

Soliman, M. T. (2008). The use of DuPont analysis by market participants. *The Accounting Review, 83*(3), 823-853. doi: https://doi.org/10.2308/accr.2008.83.3.823

Sortino, F., van der Meer, R., & Plantinga, A. (1999). The upside potential ratio. *The Journal of Performance Measurement, 1*, 10-15. Retrieved from https://research.rug.nl/en/publications/the-upside-potential-ratio

Sortino, F. A., & Van Der Meer, R. (1991). Downside risk. *Journal of portfolio Management, 17*(4), 27. Retrieved from https://www.proquest.com/openview/9698ae2e5a7f9005e71bb5a931a7ac96/1?pq-origsite=gscholar&cbl=49137

Stattman, D. (1980). Book values and stock returns. *The Chicago MBA: A journal of selected papers, 4*(1), 25-45. Retrieved from https://www.scirp.org/(S(351jmbntvnsjt1aadkposzje))/reference/ReferencesPapers.aspx?ReferenceID=2127330

Tarnaud, A. C., & Leleu, H. (2018). Portfolio analysis with DEA: Prior to choosing a model. *Omega, 75*, 57-76. doi: https://doi.org/10.1016/j.omega.2017.02.003

Traub, E. (2001). Using ROE to analyze stocks: What you need to know about. *American Association of Individual Investors (AAII) Journal, 15*(6), 97-113. Retrieved from https://www.bivio.com/garbagecop/file/Public/Webpages/EllisROEArticle.pdf

Trejo Pech, C. O., Noguera, M., & White, S. (2015). Financial ratios used by equity analysts in Mexico and stock returns. *Contaduría y Administración, 60*(3), 578-592. doi: https://doi.org/10.1016/j.cya.2015.02.001

Treynor, J. (1965). How to rate management of investment funds. *Harvard Business Review, 43*(1), 63-75. Retrieved from https://www.sid.ir/en/Journal/ViewPaper.aspx?ID=311825

Tudor, C. (2010). Firm-specific factors as predictors of future returns for Romanian common stocks: empirical evidence. *International business and Economics Department, Academy of Economics Studies from Bucharest, Romania*, 73-78. Retrieved from https://www.researchgate.net/profile/Cristiana-Tudor-3/publication/228292771

Uluyol, O., & Türk, V. E. (2013). The Effect of Financial Ratios on Firm Value: An Application in Borsa Istanbul (Bist). *Afyon Kocatepe Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi, 15*(2), 365-384. Retrieved from https://dergipark.org.tr/en/pub/akuiibfd/issue/1618/20269?publisher=aku

Van Heerden, C. (2015). The influence of higher moments and non-normality on the Sharpe ratio: A South African perspective. *Journal of Applied Business Research (JABR), 31*(1), 197-220. doi: https://doi.org/10.19030/jabr.v31i1.9001

Van Heerden, C. (2016). The eminence of risk-free rates in portfolio management: a South-African perspective. *32*(2), 569-596. doi: http://dx.doi.org/10.19030/jabr.v32i2.9597 van Heerden, C. (2020). Establishing the risk denominator in a Sharpe ratio framework for share selection from a momentum investment strategy approach. *South African Journal of Economic and Management Sciences*, *23*(1), 1-19. doi: http://dx.doi.org/10.4102/sajems.v23i1.3467

Van Heerden, C., & Heymans, A. (2013). A fundamental evaluation of the top five South African banks after the financial crisis. *Journal of Economic and Financial Sciences*, *6*(3), 729-760. Retrieved from https://hdl.handle.net/10520/EJC145347

Van Rensburg, P. (2001). A decomposition of style-based risk on the JSE. *Investment Analysts Journal*, *30*(54), 45-60. doi: https://doi.org/10.1080/10293523.2001.11082431

Weigand, R. A., & Irons, R. (2007). The market P/E ratio, earnings trends, and stock return forecasts. *The Journal of Portfolio Management*, *33*(4), 87-101. doi: https://doi.org/10.3905/jpm.2007.690610

XLSTAT. (2014). Software. Retrieved from https://www.xlstat.com/en

Young, T. W. (1991). Calmar ratio: A smoother tool. *Futures*, *20*(1), 40.

Zaremba, A., & Czapkiewicz, A. (2017). Digesting anomalies in emerging European markets: A comparison of factor pricing models. *Emerging Markets Review, 31*, 1-15. doi: https://doi.org/10.1016/j.ememar.2016.12.002

Zhu, J. (2016). DEAFrontier. Retrieved from http://www.deafrontier.net/deasupport/index.html

INTERNATIONAL JOURNAL OF ECONOMICS AND FINANCE STUDIES
Vol: 14 **No:** 02 **Year:** 2022 **ISSN**: 1309-8055 (Online) (**pp.** 686-730) **Doi:** 10.34109/ijefs. 20220059

1. APPENDIX

Table A1. The Risk-Adjusted Returns of Each Portfolio Derived from Each Ratio Relative to The Market Proxy: For 1-Year Momentum Strategy

1-year momentum strategy	2010		2011		2012		2013		2014	
	Portfolio	Market	Portfolio	Market	Portfolio	Market	Portfolio	Market	Portfolio	Market
		9.91%		1.26%		27.44%		12.06%		8.78%
		Relative to market?		Relative to market		Relative to market?		Relative to market?		Relative to market?
Jensen's Alpha	15.18%	Outperform	9.04%	Outperform	14.64%	Underperform	22.45%	Outperform	25.92%	Outperform
Kappa 3	47.03%	Outperform	18.54%	Outperform	35.96%	Outperform	32.19%	Outperform	25.44%	Outperform
Burke	33.45%	Outperform	8.96%	Outperform	37.30%	Outperform	26.90%	Outperform	25.65%	Outperform
Israelson's Modified Sharpe	29.53%	Outperform	11.44%	Outperform	35.94%	Outperform	27.42%	Outperform	22.47%	Outperform
Martin	45.28%	Outperform	18.00%	Outperform	42.04%	Outperform	21.99%	Outperform	27.96%	Outperform
Traditional Sharpe	38.35%	Outperform	9.72%	Outperform	38.13%	Outperform	20.87%	Outperform	23.13%	Outperform
Pain	42.09%	Outperform	17.97%	Outperform	60.27%	Outperform	14.78%	Outperform	21.27%	Outperform
Pezier's Adjusted Sharpe	35.27%	Outperform	9.79%	Outperform	30.54%	Outperform	26.61%	Outperform	30.58%	Outperform
Sterling	28.60%	Outperform	9.58%	Outperform	31.35%	Outperform	21.39%	Outperform	27.43%	Outperform
Sterling-Calmar	28.60%	Outperform	9.58%	Outperform	31.35%	Outperform	21.39%	Outperform	27.43%	Outperform
S*	0.74%	Underperform	19.82%	Outperform	-2.09%	Underperform	-5.77%	Underperform	1.11%	Underperform
Calmar	29.46%	Outperform	17.95%	Outperform	43.34%	Outperform	24.59%	Outperform	17.65%	Outperform
T*	8.15%	Underperform	-1.39%	Underperform	50.27%	Outperform	16.00%	Outperform	6.51%	Underperform
CVaR-Sharpe	15.16%	Outperform	15.69%	Outperform	31.66%	Outperform	22.36%	Outperform	18.30%	Outperform
SC-adjusted Sharpe	23.21%	Outperform	12.64%	Outperform	42.29%	Outperform	34.86%	Outperform	20.15%	Outperform
Omega	18.44%	Outperform	3.90%	Outperform	29.08%	Outperform	21.92%	Outperform	38.04%	Outperform
Omega-Sharpe	18.44%	Outperform	3.90%	Outperform	29.08%	Outperform	21.92%	Outperform	38.04%	Outperform
Upside Potential	3.62%	Underperform	7.40%	Outperform	24.17%	Underperform	63.48%	Outperform	23.21%	Outperform
ROA	28.52%	Outperform	15.64%	Outperform	40.21%	Outperform	6.44%	Underperform	5.14%	Underperform
Price / Book Value	11.44%	Outperform	15.27%	Outperform	7.73%	Underperform	15.65%	Outperform	17.99%	Outperform
Assets / Capital Employed	10.08%	Outperform	3.01%	Outperform	17.63%	Underperform	5.17%	Underperform	6.24%	Underperform
Debt / Assets	4.00%	Underperform	9.67%	Outperform	9.64%	Underperform	0.94%	Underperform	-3.71%	Underperform
Debt / Equity	4.99%	Underperform	1.56%	Outperform	17.84%	Underperform	19.98%	Outperform	-5.61%	Underperform
Current	-1.80%	Underperform	-8.91%	Underperform	-11.98%	Underperform	6.38%	Underperform	14.95%	Outperform
Quick	-4.98%	Underperform	-10.88%	Underperform	-14.25%	Underperform	7.86%	Underperform	14.19%	Outperform
ROCE	28.56%	Outperform	1.94%	Outperform	9.59%	Underperform	-9.24%	Underperform	15.59%	Outperform
Inflation-adjusted ROATA	23.32%	Outperform	14.49%	Outperform	40.99%	Outperform	8.66%	Underperform	1.78%	Underperform
DY	3.04%	Underperform	14.67%	Outperform	-4.84%	Underperform	-0.17%	Underperform	3.75%	Underperform

Vol: 14 No: 02 Year: 2022 ISSN: 1309-8055 (Online) (pp. 686-730) Doi: 10.34109/ijefs. 20220059

VaR-Sharpe	8.53%	Underperform	14.42%	Outperform	22.20%	Underperform	11.71%	Underperform	24.86%	Outperform

Note: The risk-adjusted returns were estimated by dividing average returns with the standard deviation.
Source: Compiled by Author

Table A1. The Risk-Adjusted Returns of Each Portfolio Derived from Each Ratio Relative to the Market Proxy: For 1-Year Momentum Strategy (Continues)

1-year momentum strategy	**2015**		**2016**		**2017**		**2018**		**2019**		**2020**	
	Portfolio	**Market**	**Portfolio**	**Market**	**Portfolio**	**Market**	**Portfolio**	**Market**	**Portfolio**	**Market**	**Portfolio**	**Market**
		1.19%		0.41%		13.38%		-11.40%		7.34%		1.62%
		Relative to market?		Relative to market?		Relative to market?		Relative to market?		Relative to market?		Relative to market?
Jensen's Alpha	6.94%	Outperform	1.77%	Outperform	4.48%	Underperform	-8.72%	Outperform	-3.86%	Underperform	-8.86%	Underperform
Kappa 3	-0.11%	Underperform	6.13%	Outperform	0.86%	Underperform	-18.13%	Underperform	-10.73%	Underperform	-5.28%	Underperform
Burke	-3.77%	Underperform	6.58%	Outperform	7.98%	Underperform	-12.20%	Underperform	-5.49%	Underperform	-4.07%	Underperform
Israelson's Modified Sharpe	-3.84%	Underperform	5.53%	Outperform	3.10%	Underperform	-10.20%	Outperform	-9.74%	Underperform	-2.05%	Underperform
Martin	-0.68%	Underperform	2.09%	Outperform	7.16%	Underperform	-17.59%	Underperform	-6.07%	Underperform	-5.76%	Underperform
Traditional Sharpe	-3.45%	Underperform	2.70%	Outperform	11.40%	Underperform	-12.58%	Underperform	-2.01%	Underperform	-11.43%	Underperform
Pain	3.64%	Outperform	2.56%	Outperform	-6.76%	Underperform	-14.61%	Underperform	-10.79%	Underperform	-13.71%	Underperform
Pezier's Adjusted Sharpe	-3.13%	Underperform	2.55%	Outperform	7.40%	Underperform	-11.55%	Underperform	-4.86%	Underperform	-3.97%	Underperform
Sterling	-0.65%	Underperform	4.64%	Outperform	9.84%	Underperform	-10.81%	Outperform	-4.91%	Underperform	-3.49%	Underperform
Sterling-Calmar	-0.65%	Underperform	4.64%	Outperform	9.84%	Underperform	-10.81%	Outperform	-4.91%	Underperform	-3.49%	Underperform
S*	3.42%	Outperform	0.65%	Outperform	-15.64%	Underperform	-4.77%	Outperform	-14.80%	Underperform	-2.96%	Underperform
Calmar	11.80%	Outperform	-0.79%	Underperform	14.59%	Outperform	-17.86%	Underperform	3.20%	Underperform	-6.44%	Underperform
T*	-6.15%	Underperform	-3.80%	Underperform	-0.33%	Underperform	-11.13%	Outperform	-5.27%	Underperform	-16.54%	Underperform
CVaR-Sharpe	9.78%	Outperform	-7.23%	Underperform	9.59%	Underperform	-17.78%	Underperform	-6.76%	Underperform	-6.77%	Underperform
SC-adjusted Sharpe	-0.71%	Underperform	11.28%	Outperform	-3.79%	Underperform	-20.26%	Underperform	-9.18%	Underperform	-5.44%	Underperform
Omega	4.25%	Outperform	7.58%	Outperform	-8.30%	Underperform	-18.33%	Underperform	-15.36%	Underperform	-6.11%	Underperform
Omega-Sharpe	4.25%	Outperform	7.58%	Outperform	-8.30%	Underperform	-18.33%	Underperform	-15.36%	Underperform	-6.11%	Underperform
Upside Potential	10.28%	Outperform	-11.55%	Underperform	15.93%	Outperform	-3.24%	Outperform	-4.30%	Underperform	-9.84%	Underperform
ROA	-10.31%	Underperform	9.26%	Outperform	2.02%	Underperform	-12.67%	Underperform	-7.32%	Underperform	-2.34%	Underperform
Price / Book Value	10.00%	Outperform	1.77%	Outperform	1.81%	Underperform	-9.19%	Outperform	-24.20%	Underperform	-1.61%	Underperform
Assets / Capital Employed	-3.90%	Underperform	1.84%	Outperform	10.18%	Underperform	-11.69%	Underperform	-11.85%	Underperform	-3.13%	Underperform
Debt / Assets	1.49%	Outperform	24.39%	Outperform	-7.88%	Underperform	-8.49%	Outperform	-4.40%	Underperform	1.42%	Underperform

Debt / Equity	-18.25%	Underperform	8.18%	Outperform	-16.71%	Underperform	-28.80%	Underperform	-22.14%	Underperform	-16.37%	Underperform
Current	-3.22%	Underperform	-5.46%	Underperform	-20.54%	Underperform	-14.69%	Underperform	-1.34%	Underperform	-6.85%	Underperform
Quick	-6.66%	Underperform	-3.11%	Underperform	-24.83%	Underperform	-14.61%	Underperform	2.00%	Underperform	-5.24%	Underperform
ROCE	4.59%	Outperform	0.45%	Outperform	8.40%	Underperform	-12.56%	Underperform	-12.78%	Underperform	-3.38%	Underperform
Inflation-adjusted ROATA	-8.08%	Underperform	7.74%	Outperform	0.92%	Underperform	-16.71%	Underperform	-5.48%	Underperform	-5.59%	Underperform
DY	-14.04%	Underperform	2.66%	Outperform	-11.71%	Underperform	-0.56%	Outperform	-5.07%	Underperform	-7.84%	Underperform
VaR-Sharpe	7.35%	Outperform	-1.51%	Underperform	-1.72%	Underperform	-12.08%	Underperform	-12.65%	Underperform	-9.17%	Underperform

Note: The risk-adjusted returns were estimated by dividing average returns with the standard deviation.
Source: Compiled by Author

Table A2: The Risk-Adjusted Returns of Each Portfolio Derived from Each Ratio Relative to The Market Proxy: For 3-Years Momentum Strategy

3-years momentum strategy	**2012**		**2013**		**2014**		**2015**	
	Portfolio	**Market**	**Portfolio**	**Market**	**Portfolio**	Market	**Portfolio**	**Market**
		9,67%		10,52%		13,89%		6,89%
		Relative to market?		Relative to market?		Relative to market?		Relative to market?
Jensen's Alpha	12,78%	Outperform	14,89%	Outperform	20,30%	Outperform	17,94%	Outperform
Kappa 3	28,73%	Outperform	25,09%	Outperform	29,01%	Outperform	15,58%	Outperform
Burke	22,82%	Outperform	21,44%	Outperform	26,77%	Outperform	12,09%	Outperform
Israelson's Modified Sharpe	21,64%	Outperform	21,98%	Outperform	27,00%	Outperform	10,76%	Outperform
Martin	29,31%	Outperform	23,18%	Outperform	27,75%	Outperform	13,74%	Outperform
Traditional Sharpe	25,05%	Outperform	20,75%	Outperform	24,91%	Outperform	10,83%	Outperform
Pain	30,08%	Outperform	21,71%	Outperform	23,21%	Outperform	12,79%	Outperform
Pezier's Adjusted Sharpe	22,10%	Outperform	20,51%	Outperform	27,51%	Outperform	13,21%	Outperform
Sterling	20,34%	Outperform	18,53%	Outperform	24,67%	Outperform	12,80%	Outperform
Sterling-Calmar	20,34%	Outperform	18,53%	Outperform	24,67%	Outperform	12,80%	Outperform
S*	4,93%	Underperform	3,62%	Underperform	-1,48%	Underperform	0,28%	Underperform
Calmar	28,05%	Outperform	26,52%	Outperform	26,54%	Outperform	17,09%	Outperform
T*	11,36%	Outperform	15,26%	Outperform	16,90%	Outperform	3,41%	Underperform
CVaR-Sharpe	19,31%	Outperform	22,40%	Outperform	23,52%	Outperform	15,44%	Outperform
SC-adjusted Sharpe	20,94%	Outperform	25,85%	Outperform	29,13%	Outperform	11,76%	Outperform
Omega	15,34%	Outperform	16,26%	Outperform	28,71%	Outperform	16,90%	Outperform
Omega-Sharpe	15,34%	Outperform	16,26%	Outperform	28,71%	Outperform	16,90%	Outperform
Upside Potential	10,35%	Outperform	22,40%	Outperform	29,94%	Outperform	21,50%	Outperform
ROA	25,62%	Outperform	17,78%	Outperform	14,38%	Outperform	-0,96%	Underperform

Vol: 14 **No:** 02 **Year:** 2022 **ISSN**: 1309-8055 (Online) (**pp.** 686-730) **Doi:** 10.34109/ijefs. 20220059

Price / Book Value	10,98%	Outperform	12,31%	Outperform	12,92%	Underperform	13,60%	Outperform
Assets / Capital Employed	10,46%	Outperform	8,92%	Underperform	9,68%	Underperform	2,05%	Underperform
Debt / Assets	7,84%	Underperform	6,79%	Underperform	2,43%	Underperform	-0,42%	Underperform
Debt / Equity	8,20%	Underperform	13,16%	Outperform	10,56%	Underperform	-1,19%	Underperform
Current	-6,96%	Underperform	-3,66%	Underperform	5,87%	Underperform	6,53%	Underperform
Quick	-9,59%	Underperform	-3,80%	Underperform	5,50%	Underperform	5,39%	Underperform
ROCE	12,66%	Outperform	1,61%	Underperform	4,33%	Underperform	2,51%	Underperform
Inflation-adjusted ROATA	23,38%	Outperform	18,69%	Outperform	14,27%	Outperform	-0,25%	Underperform
DY	3,29%	Underperform	2,44%	Underperform	0,13%	Underperform	-3,23%	Underperform
VaR-Sharpe	14,37%	Outperform	15,52%	Outperform	18,28%	Outperform	12,96%	Outperform

Note: The risk-adjusted returns were estimated by dividing average returns with the standard deviation.
Source: Compiled by Author

Table A2. The Risk-Adjusted Returns of Each Portfolio Derived from Each Ratio Relative to the Market Proxy: For 3-Years Momentum Strategy (Continues)

3-years momentum strategy	**2016**		**2017**		**2018**		**2019**		**2020**	
	Portfolio	**Market**	**Portfolio**	**Market**	**Portfolio**	**Market**	**Portfolio**	**Market**	**Portfolio**	**Market**
		3.34%		4.81%		0.98%		3.23%		0.23%
		Relative to market?		Relative to market?		Relative to market?		Relative to market?		Relative to market?
Jensen's Alpha	12.52%	Outperform	4.27%	Underperform	-0.41%	Underperform	-2.12%	Underperform	-6.71%	Underperform
Kappa 3	9.42%	Outperform	2.66%	Underperform	-2.36%	Underperform	-9.58%	Underperform	-7.64%	Underperform
Burke	7.81%	Outperform	2.32%	Underperform	0.15%	Underperform	-4.49%	Underperform	-5.43%	Underperform
Israelson's Modified Sharpe	5.71%	Outperform	1.52%	Underperform	0.19%	Underperform	-6.50%	Underperform	-4.56%	Underperform
Martin	8.34%	Outperform	2.34%	Underperform	-2.18%	Underperform	-5.26%	Underperform	-7.20%	Underperform
Traditional Sharpe	6.15%	Outperform	2.24%	Underperform	-0.10%	Underperform	-1.89%	Underperform	-7.95%	Underperform
Pain	8.88%	Outperform	0.28%	Underperform	-5.50%	Underperform	-10.17%	Underperform	-12.01%	Underperform
Pezier's Adjusted Sharpe	7.40%	Outperform	1.14%	Underperform	-0.94%	Underperform	-3.96%	Underperform	-4.96%	Underperform
Sterling	8.76%	Outperform	3.34%	Underperform	-0.17%	Underperform	-3.78%	Underperform	-4.91%	Underperform
Sterling-Calmar	8.76%	Outperform	3.34%	Underperform	-0.17%	Underperform	-3.78%	Underperform	-4.91%	Underperform
S*	1.67%	Underperform	-3.51%	Underperform	-6.21%	Underperform	-10.68%	Underperform	-5.48%	Underperform
Calmar	8.53%	Outperform	9.07%	Outperform	2.28%	Outperform	3.23%	Outperform	-5.44%	Underperform
T*	-1.62%	Underperform	-3.73%	Underperform	-5.12%	Underperform	-5.43%	Underperform	-10.51%	Underperform
CVaR-Sharpe	6.05%	Outperform	4.07%	Underperform	-5.56%	Underperform	-5.50%	Underperform	-7.74%	Underperform
SC-adjusted Sharpe	7.87%	Outperform	2.67%	Underperform	-2.20%	Underperform	-10.02%	Underperform	-7.28%	Underperform
Omega	12.72%	Outperform	1.68%	Underperform	-6.55%	Underperform	-13.41%	Underperform	-8.99%	Underperform

Omega-Sharpe	12.72%	Outperform	1.68%	Underperform	-6.55%	Underperform	-13.41%	Underperform	-8.99%	Underperform
Upside Potential	5.63%	Outperform	3.99%	Underperform	-1.18%	Underperform	0.59%	Underperform	-6.34%	Underperform
ROA	1.76%	Underperform	1.30%	Underperform	2.32%	Outperform	-4.88%	Underperform	-4.17%	Underperform
Price / Book Value	9.62%	Outperform	5.22%	Outperform	-3.21%	Underperform	-11.35%	Underperform	-8.71%	Underperform
Assets / Capital Employed	1.19%	Underperform	0.66%	Underperform	-2.94%	Underperform	-7.92%	Underperform	-6.79%	Underperform
Debt / Assets	3.78%	Outperform	3.22%	Underperform	-1.05%	Underperform	-6.55%	Underperform	-3.19%	Underperform
Debt / Equity	-4.69%	Underperform	-9.44%	Underperform	-12.77%	Underperform	-21.12%	Underperform	-21.25%	Underperform
Current	3.73%	Outperform	-8.01%	Underperform	-12.59%	Underperform	-7.44%	Underperform	-5.64%	Underperform
Quick	2.92%	Underperform	-9.30%	Underperform	-12.61%	Underperform	-6.43%	Underperform	-3.83%	Underperform
ROCE	4.48%	Outperform	4.13%	Underperform	0.31%	Underperform	-5.05%	Underperform	-6.00%	Underperform
Inflation-adjusted ROATA	1.55%	Underperform	1.36%	Underperform	0.60%	Underperform	-5.15%	Underperform	-5.78%	Underperform
DY	-2.01%	Underperform	-6.96%	Underperform	-2.70%	Underperform	-5.72%	Underperform	-5.17%	Underperform
VaR-Sharpe	7.64%	Outperform	1.39%	Underperform	-4.90%	Underperform	-8.98%	Underperform	-8.72%	Underperform

Note: The risk-adjusted returns were estimated by dividing average returns with the standard deviation.
Source: Compiled by Author

Table A3. The Risk-Adjusted Returns of Each Portfolio Derived from Each Ratio Relative to the Market Proxy: For 5-Years Momentum Strategy

5-years momentum strategy	**2014**		**2015**		**2016**		**2017**		**2018**	
	Portfolio	**Market**	**Portfolio**	**Market**	**Portfolio**	**Market**	**Portfolio**	**Market**	**Portfolio**	**Market**
		9.97%		7.87%		7.95%		6.96%		2.47%
		Relative to market?		Relative to market?		Relative to market?		Relative to market?		Relative to market?
Jensen's Alpha	16.95%	Outperform	15.44%	Outperform	14.42%	Outperform	11.76%	Outperform	6.49%	Outperform
Kappa 3	28.22%	Outperform	18.21%	Outperform	14.93%	Outperform	10.89%	Outperform	3.45%	Outperform
Burke	23.82%	Outperform	13.38%	Outperform	12.66%	Outperform	10.13%	Outperform	3.92%	Outperform
Israelson's Modified Sharpe	22.58%	Outperform	13.26%	Outperform	11.17%	Outperform	8.03%	Outperform	2.47%	Underperform
Martin	27.33%	Outperform	17.21%	Outperform	13.44%	Outperform	9.95%	Outperform	3.79%	Outperform
Traditional Sharpe	23.64%	Outperform	13.23%	Outperform	11.41%	Outperform	8.95%	Outperform	3.40%	Outperform
Pain	24.36%	Outperform	17.09%	Outperform	13.43%	Outperform	7.04%	Outperform	2.01%	Underperform
Pezier's Adjusted Sharpe	24.40%	Outperform	13.93%	Outperform	11.91%	Outperform	9.73%	Outperform	3.92%	Outperform
Sterling	21.73%	Outperform	13.76%	Outperform	12.35%	Outperform	10.29%	Outperform	4.59%	Outperform
Sterling-Calmar	21.73%	Outperform	13.76%	Outperform	12.35%	Outperform	10.29%	Outperform	4.59%	Outperform
S*	2.39%	Underperform	2.89%	Underperform	-0.16%	Underperform	-2.50%	Underperform	-2.62%	Underperform
Calmar	25.05%	Outperform	20.75%	Outperform	15.58%	Outperform	11.78%	Outperform	5.52%	Outperform

Vol: 14 **No:** 02 **Year:** 2022 **ISSN**: 1309-8055 (Online) (**pp.** 686-730) **Doi:** 10.34109/ijefs. 20220059

T*	11.03%	Outperform	6.66%	Underperform	5.53%	Underperform	1.27%	Underperform	-3.12%	Underperform
CVaR-Sharpe	19.14%	Outperform	18.32%	Outperform	12.89%	Outperform	9.12%	Outperform	1.51%	Underperform
SC-adjusted Sharpe	22.84%	Outperform	14.18%	Outperform	13.82%	Outperform	9.27%	Outperform	1.58%	Underperform
Omega	19.61%	Outperform	15.66%	Outperform	16.86%	Outperform	10.48%	Outperform	2.95%	Outperform
Omega-Sharpe	19.61%	Outperform	15.66%	Outperform	16.86%	Outperform	10.48%	Outperform	2.95%	Outperform
Upside Potential	16.27%	Outperform	18.78%	Outperform	13.90%	Outperform	12.09%	Outperform	5.31%	Outperform
ROA	17.26%	Outperform	7.79%	Underperform	6.76%	Underperform	2.47%	Underperform	0.08%	Underperform
Price / Book Value	12.97%	Outperform	12.61%	Outperform	10.05%	Outperform	9.27%	Outperform	3.31%	Outperform
Assets / Capital Employed	8.51%	Underperform	5.29%	Underperform	4.96%	Underperform	2.67%	Underperform	-1.39%	Underperform
Debt / Assets	4.06%	Underperform	3.54%	Underperform	4.50%	Underperform	1.18%	Underperform	-1.04%	Underperform
Debt / Equity	7.78%	Underperform	2.92%	Underperform	4.13%	Underperform	-4.46%	Underperform	-11.97%	Underperform
Current	2.72%	Underperform	2.17%	Underperform	2.11%	Underperform	1.02%	Underperform	-2.00%	Underperform
Quick	1.86%	Underperform	0.99%	Underperform	1.57%	Underperform	0.48%	Underperform	-2.79%	Underperform
ROCE	8.58%	Underperform	3.86%	Underperform	3.37%	Underperform	3.09%	Underperform	3.01%	Outperform
Inflation-adjusted ROATA	16.03%	Outperform	8.92%	Outperform	7.31%	Underperform	2.30%	Underperform	-0.81%	Underperform
DY	2.86%	Underperform	-0.92%	Underperform	-2.19%	Underperform	-3.35%	Underperform	-3.37%	Underperform
VaR-Sharpe	15.12%	Outperform	14.81%	Outperform	10.88%	Outperform	6.64%	Underperform	1.87%	Underperform

Note: The risk-adjusted returns were estimated by dividing average returns with the standard deviation.
Source: Compiled by Author

Table A3. The Risk-Adjusted Returns of Each Portfolio Derived from Each Ratio Relative to The Market Proxy: For 5-Years Momentum Strategy (Continues)

5-years momentum strategy	**2019**		**2020**	
	Portfolio	**Market**	**Portfolio**	**Market**
		2.28%		1.98%
		Relative to market?		Relative to market?
Jensen's Alpha	-0.41%	Underperform	-3.31%	Underperform
Kappa 3	-4.04%	Underperform	-4.49%	Underperform
Burke	-2.17%	Underperform	-2.37%	Underperform
Israelson's Modified Sharpe	-3.06%	Underperform	-2.21%	Underperform
Martin	-2.85%	Underperform	-3.93%	Underperform
Traditional Sharpe	-1.29%	Underperform	-4.36%	Underperform
Pain	-5.15%	Underperform	-8.62%	Underperform
Pezier's Adjusted Sharpe	-2.41%	Underperform	-2.60%	Underperform
Sterling	-1.43%	Underperform	-2.13%	Underperform
Sterling-Calmar	-1.43%	Underperform	-2.13%	Underperform

S*	-5.72%	Underperform	-5.83%	Underperform
Calmar	3.86%	Outperform	-0.48%	Underperform
T*	-5.28%	Underperform	-8.04%	Underperform
CVaR-Sharpe	-2.56%	Underperform	-5.38%	Underperform
SC-adjusted Sharpe	-3.58%	Underperform	-4.20%	Underperform
Omega	-6.22%	Underperform	-6.65%	Underperform
Omega-Sharpe	-6.22%	Underperform	-6.65%	Underperform
Upside Potential	0.70%	Underperform	-4.57%	Underperform
ROA	-2.07%	Underperform	-0.97%	Underperform
Price / Book Value	-4.56%	Underperform	-5.89%	Underperform
Assets / Capital Employed	-5.46%	Underperform	-4.32%	Underperform
Debt / Assets	-1.35%	Underperform	-1.08%	Underperform
Debt / Equity	-14.93%	Underperform	-15.13%	Underperform
Current	-6.26%	Underperform	-6.63%	Underperform
Quick	-5.92%	Underperform	-5.25%	Underperform
ROCE	-1.51%	Underperform	-3.07%	Underperform
Inflation-adjusted ROATA	-2.43%	Underperform	-2.76%	Underperform
DY	-5.48%	Underperform	-4.57%	Underperform
VaR-Sharpe	-4.19%	Underperform	-6.61%	Underperform

Note: The risk-adjusted returns were estimated by dividing average returns with the standard deviation.
Source: Compiled by Author