“Enhancing portfolio resilience during crisis periods: Lessons from BRICS indices and multi asset strategies”

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ENHANCING PORTFOLIO RESILIENCE DURING CRISIS PERIODS: LESSONS FROM BRICS INDICES AND MULTI ASSET STRATEGIES

Abstract

This paper uses Markowitz's mean-variance model to construct an investment portfolio incorporating multiple assets – BRICS equity indices, Gold, crude oil, bonds, and cryptocurrencies. The optimally created risky portfolios outperform alternative portfolio optimization methods – the naive portfolio and the equal risk contribution portfolio; and established indices – the S&P 500 and the MSCI Emerging Equity Index in terms of metrics – adjusted Sharpe ratio, modified Sharpe ratio, and the modified Value at Risk. The findings are validated across different periods, including the COVID-19 period and the Russian invasion of Ukraine, including various in and out of sample periods. The findings highlight the benefits of portfolio diversity, mainly using BRICS indices, Gold, and Brent Crude oil, and challenge the notion of limited diversification benefits in BRICS indices found in previous studies. This paper further suggests the potential of emerging market bonds ETF as a diversification option during turbulent economic periods and highlights the limitations of cryptocurrencies in optimizing multi asset portfolios. By adopting the recommended multi asset portfolios, investors can enhance their risk-return trade-offs and achieve superior performance compared to the S&P500 and MSCI emerging indices. Lastly, the paper recommends future research opportunities in measuring portfolio performance and hedging strategies considering risk-adjusted return measurements, transaction expenses, and dynamic rebalancing techniques.

Keywords multi asset, risky portfolio, naive portfolio, equal risk contribution portfolio, adjusted Sharpe ratio, modified Sharpe ratio, value at risk

JEL Classification G11, G12, F21

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INTRODUCTION

Markowitz said in his seminal 1952 paper, "*The only free lunch in finance is diversification*". Informed investors are keen to use portfolio diversification to reduce the risk of their investments. They are ready to go beyond the national boundaries in their pursuit of diversification to minimize the risk of their investments. Since the 1980s, world capital markets have become increasingly deregulated and opened up opportunities for international investment. Opening up the global financial markets has increased the preference of investors for cross-border investments as a way to diversify their portfolios.

The unprecedented COVID-19 pandemic plunged humanity into crisis, catching the world off guard and disrupting the global landscape in previously unimaginable ways. Beyond its devastating impact on public health, the pandemic reverberated across the global economy and sent shockwaves through the financial markets. As the world adjusted to the "new normal" imposed by the pandemic, the Russian

invasion of Ukraine in February 2022 further destabilized the world stage and crude oil prices. In such turbulent times, the task of portfolio managers became exceptionally challenging. Balancing portfolios across various asset classes while consistently delivering positive risk-adjusted returns becomes formidable. Consequently, it has become imperative for portfolio managers to explore different asset classes and returns, outperforming popular benchmarks such as the S&P500, the broad-based Index for developed markets, and the MSCI market index for emerging markets.

For several compelling reasons, BRICS equities continue to shine in the contemporary financial landscape. The brilliant performance of BRICS equities in contemporary times can be attributed to their favorable growth prospects, expanding global significance, improved business environments, enhanced accessibility, interconnectedness with global markets, and regional economic cooperation. BRICS countries have exhibited considerable momentum in their financial market, creating a prospective hub for international investors. This paper recommends the creation of a multi asset portfolio for international investors comprising emerging market equities indices of BRICS countries along with other select asset classes, which generate better risk-adjusted returns and have exhibited resilience during crisis periods.

1. LITERATURE REVIEW

Diversifying investments across asset classes and nations reduce portfolio risks. Multi asset portfolios deliver greater liquidity, stepped-forward variety, and decreased volatility (Vo & Tran, 2020) and can match effectively alongside numerous investment procedures and asset categories (Peskin, 2018). Foreign investors look to diversify their portfolios in emerging markets, like BRICS, which also benefits those firms (Vo & Chu, 2019). With significant foreign investment flows, the volatility of oil prices will be very significant for emerging economies such as BRICS countries (Naeem et al., 2022). Advanced economies are getting integrated with BRICS economies (Majumder, 2012). The study done by Buchanan et al. (2021) found that including BRICS equity indices in a multiasset portfolio increases risk-adjusted returns.

Apart from BRICS equities, commodities also add dimensions to a multi asset portfolio. Gold is one such commodity. Gold is an effective hedge for debt and equity markets with an investment horizon of one year (Bredin et al., 2015). Gold has also emerged as an option for a safe investment for equity investors interested in long-term investments, particularly during times of financial turmoil. Aboura (2016) found Gold essential in a multi asset portfolio constructed with commodities as an asset class across all economic regimes. Dong Yoon (2021) found that Gold's hedging role concerning stock differs in everyday and extreme market situations. In 2008, with the onset of the global financial crisis, Gold proved to be a safe bet in a multi asset portfolio. The safe haven properties of Gold were again witnessed during the COVID-19 period. However, the diversification properties of Gold weakened as the COVID-19 pandemic intensified, as noted by Ren et al. (2021).

Crude oil futures are another commodity that adds to the diversification benefits of a multi asset portfolio. The relationship of oil with the economic markets is a well-researched topic (Alquist & Gervais, 2013; Zhang & Wang, 2015; Ma et al., 2019). Wang et al. (2020) study found that the equity markets of BRICS strongly correlate to the WTI Crude under severe circumstances. Consequently, mentioning WTI provides no diversification advantages to a BRICS portfolio. Nunez-Mora and Sachchez-Ruenes (2020) covered oil mixes and BRICS equity indices to assemble a multi asset portfolio. Their research observed that India, China, and Brazil's equity indices and oil mixes of China and Brazil contribute to portfolio performance. However, the Russian equity index and oil mix contributed significantly to the portfolio's efficient frontier. Wang et al. (2022) discovered that portfolio diversification in a multi asset portfolio using energy futures provided higher risk-adjusted returns for all energy futures markets except for WTI crude oil futures for the study, a period between 2011–2020. In maximum allocation strategies, using energy futures facilitates and enhances the overall performance of a bond-stock portfolio (Bessler & Wolff, 2015).

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Apart from equities and commodities, bonds as an asset have gained popularity during the past decade, and institutional investors have primarily embraced this asset as a new asset class (Sterge & Van der Stichele, 2016). Brinson et al. (1991) used stock and bond market assets to analyze performance in a multi asset portfolio created for long-term investors. The structure of bonds segregates investors from market-related risk to event-related risk, which is why they have become an essential source of portfolio diversification (Litzenberger et al., 1996). A study by Kish (2016) found that bonds could provide benefits of diversification when added to an investor's portfolio comprising stocks, commodities, and real estate. The empirical research works of other researchers reveal that tail risk and drawdown measures under various market regimes can be brought down by using bonds (Clark et al., 2016; Sterge & van der Stichele, 2016). Bonds can act as an effective diversifier; however, in some cases, they may be a poor hedge but can emerge as a good haven when there is a downward movement in stock prices during the post-crisis period (Drobetz et al., 2020).

A substantial body of research has focused on the correlation between cryptocurrencies and other financial assets. In a study conducted in U.S. markets from 2010–2013, Briere et al. (2015) found that investment portfolios with crypto assets have a better risk-return ratio than portfolios without it. Wu and Pandey (2014) found that incorporating Bitcoins in a portfolio enhances portfolio returns and mitigates the risk of losses. Corbet et al. (2018) for the period covering 2013–2017, found crypto assets to have a low correlation with traditional financial markets. Therefore, including crypto assets in a multi asset portfolio would benefit investors. Bouri et al. (2017) found evidence of Bitcoin being a good diversification asset in a multi asset portfolio. Studies by Koziuk (2022) (for countries with worsening inflation and institutional performance) and Akyildirim et al. (2021) (during pandemic times) found the inclusion of cryptocurrencies in multi asset portfolios to improve risk-return performance.

Based on the review of the past studies, the authors find a gap in the literature, as very few studies have taken the joint inclusion of these multi assets in a global portfolio, especially during times of stress. The paper attempts to achieve the following research questions:

1. Construct multi asset portfolios for international investors in a way that delivers better risk-adjusted returns and shows less vulnerability to incidences of extreme fall in portfolio value in times of stress.

2. Suggest the best portfolio construction method among the popular portfolio construction methods, which provides better risk-adjusted returns over popular indices- S&P 500 and MSCI Emerging market indices.

2. METHOD

The authors have collected daily data of stock indices of respective BRICS countries, Brent crude oil prices in USD, gold prices in USD, JP Morgan emerging bond index in USD, and a value-weighted cryptocurrency index as constructed by Gupta et al. (2023) for the period January 3, 2018, to June 14, 2023. Table 1 tabularizes the assets taken as variables in the study. The study period is categorized into COVID-19 from January 3, 2018, to March 18, 2020, comprising 457 observations. The post-COVID-19 period has been taken from September 30, 2020, to January 31, 2022, comprising 290 observations. The third phase covers the Russian invasion of Ukraine from February 1, 2022, to February 28, 2023. For each phase, a post-sample (also called the out-of-sample) period was calculated by taking 30% of the following date's data of the in-sample period.

The pre-COVID out-of-sample period was taken from March 19, 2020, to February 18, 2021, covering 196 observations, and the post-COVID out-of-sample period covered the period from February 1, 2022, to August 25, 2022. This phase also coincided with the onset of the Russo-Ukraine war. Hence, the period was again highly volatile, covering 124 observations. The post-Russo-Ukraine war out-of-sample period was taken from March 1, 2023, to June 14, 2023. Given the contemporary nature of the data, this period was the maximum that could be used and hence did not confirm the thumb rule of out-of-sample calculation. It includes 69 observations.

Table 1. Variables used in the study

Asset	Representation	Source	Symbol
BRICS Equity	The leading stock market index represents BOVESPA (Brazil), MOEX(Russia), SENSEX(India), SSE(China), STOP40 (South Africa)	www.yahoofinance.com	LNBOV LNMOEX LNSEN LNSSE LNSTOP
Gold	Gold Futures Prices in USD	www.investing.com	LNGOLD
Debt	iShares JP Morgan USD Emerging Markets Bond ETF	www.yahoofinance.com	LNEMB
Crude	Brent Crude oil futures prices in USD	www.investing.com	LNCRUDE
Cryptocurrency	CRYPTO7 Crypto Index was created using seven cryptocurrencies using value-weighted methodology: Bitcoin, Ethereum, Tether, Binance Coin, Ripple, Cardano, Dogecoin	www.yahoofinance.com *Source: Gupta et al.2023*	LNCRYPTO7
Emerging Equity Market Index	MSCI Emerging Market Index	www.investing.com	LNMSCI
US Broad-Based Equity Index	S&P 500	www.investing.com	LNS&P500

The Optimal risky, Naïve and Equal Risk contributions methods create multi asset portfolios. Microsoft Excel Solver has been used to create the portfolios using the GRG Nonlinear method with non-negativity constraints. Hence, short selling was prohibited while calculating asset weights under each method. The multiple ways of portfolio evaluation using risk-adjusted methods – Adjusted Sharpe ratio, Modified Sharpe ratio, and the Value of Risk method – have added to the robustness of the study.

Optimal Risky Portfolio: The mean-variance model based on the portfolio selection theory introduced by the economist Harry Markowitz (1952, 1959) utilizes quantitative techniques, such as mean-variance optimization or other advanced optimization algorithms, to determine the allocation of assets that provide the highest Sharpe ratio or another risk-adjusted performance measure. The return on security *i* is given by:

$$R = \frac{\left(P_1 - P_0\right)}{P_0}, \quad (1)$$

where P_1 and P_0 are the share prices at time *t* and *t* – 1, respectively.

The investor attains the expected return by adopting a variance of return and reducing the variance in expected return through diversified asset allocation in a portfolio. The asset allocation process is done by allotting the optimal weights of investments to risky assets. The weights become optimal when the portfolio attains expected utility maximization and risk minimization for risk-averse investors (Moulya et al., 2019).

Naive Portfolio: The naive portfolio construction method, an equally weighted portfolio, assigns equal weights to all assets without considering their individual risk or return characteristics. The framework of mean-variance, as proposed by Markowitz (1952), is well accepted in all modern portfolio theories where the investors follow the naïve (1/N) diversification strategy for allocating their investments across various assets (Berbartzi & Thaler, 2001; Brown et al., 2007). The main attraction of this approach is its simplicity, where a fraction of 1/N of wealth is allocated to each of the N assets available for investment. Generally, the equation for the variance of the portfolio with n as the size of its distribution in the following way:

$$\sigma_p^2 = \sum_{i-1}^{n}\sum_{j-1}^{n} w_i w_j Cov\left(r_i, r_j\right). \quad (2)$$

Here w_i and w_j are the proportion of investment of assets (*i* and *j*), and r_i and r_j are considered as return of the assets (*i* and *j*), respectively. The covariance of the returns between the assets is represented by cov (r_i, r_j). When an equally weighted portfolio is formed using the naïve diversification, we get $w_i = w_j = 1 / n$, and the equation (1) can be represented as:

$$\sigma_p^2 = \frac{1}{n}\sum_{i-1}^{n}\frac{1}{n}\sigma_i^2 + \sum_{i=1 i\neq j}^{n}\sum_{j=1}^{n}\frac{1}{n^2}Cov\left(ri, rj\right). \quad (3)$$

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Equal Risk Portfolio: A mean-free strategy suggests that it will result in equal risk from each asset in the portfolio from a risk perspective (Maillard et al., 2010). It allocates the weights based on the assets' volatilities and correlations, ensuring that each asset contributes equally to the overall portfolio risk. It provides a systematic way to balance risk across assets and can help manage downside risk and improve portfolio stability.

Let the risk of portfolio x be measured by $R(x)$ and the risk contribution of asset i be represented as $Ci(x)$. Then, as per the definition, it is held that

$$R(x) = \sum_{i=1}^{N} Ci(x). \quad (4)$$

If the variance of its return measures the portfolio's risk, then $R(x) = x^T Qx$ and $Ci(x) = xi(Qx)i$, where

$$(Qx)i = \sum_{j=1}^{N} Qijxj. \quad (5)$$

In this equation T denotes the transpose and Qx denotes the estimated variance covariance matrix of the asset return. Qij is the covariance between assets and xj is the acceptable weight of the portfolio that will make it feasible.

Similarly, if we use the standard deviation of the return as the risk measure yields

$$R(x) = \sqrt{x^T Qx}, \text{ and } Ci(x.) = \frac{xi(Qx)i}{\sqrt{x^T Qx}}). \quad (6)$$

An *ERC* portfolio x^{ERC} satisfies the following:

$$Ci(x^{ERC}) = \frac{R(x^{ERC})}{N}, \quad \text{for } i = 1,2,\ldots.N. \quad (7)$$

Since $xi(Qx)i = xi(Qx)i / N$ if and only if

$$\frac{xi(Qx)i)}{\sqrt{xTQx}} = \frac{\sqrt{xTQx}}{N}. \quad (8)$$

In an ERC portfolio, one considers only the variance risk measure, recognizing that all results will be applied equally to the standard deviation (Mausser & Romanko, 2014).

In the current study, as the asset returns exhibited non-normal properties, as measured by the Jarque Bera test (see Table 2), the Adjusted Sharpe Ratio (ASR) is used to evaluate portfolio performance. There are various ways to calculate an adjusted Sharpe ratio (Maillard, 2018). One of the methods is presented here:

$$ASR = SR\left(1 + \frac{S}{6}SR - \frac{K-3}{24}SR^2\right), \quad (9)$$

where S is the skewness of the distribution of return and kurtosis is represented as K, which can be computed by the third and fourth moment of the distribution, have represented the skewness. Pézier and White (2008) and Kryzanowshi et al. (2018) have subsequently used this simple and manageable definition of an Adjusted Sharpe ratio.

When two assets have the same return, the asset with the lower risk will be chosen, so the worse asset should be measured when there is more significant risk involved and this will resolve any inconsistency that may occur due to inadequate treatment of risk in the original Sharpe ratio for certain circumstances.

In mathematical terms, the partial derivatives of an efficiency index for a given risk parame-

Table 2. Test of normality using Jarque-Bera test results: Period: 3/1/2018 to 14/6/2018

S.No.	Asset	J.B. Value	p Value	Interpretation
1	LNBOVESPA	12968.36	<0.05	Data is Nonnormal
2	LNMOEX	1219098.18	<0.05	Data is Nonnormal
3	LNSEN	4408.40	<0.05	Data is Nonnormal
4	LNSSE	3332.25	<0.05	Data is Nonnormal
5	LNSTOP	2381.07	<0.05	Data is Nonnormal
6	LNEMB	152424.65	<0.05	Data is Nonnormal
7	LNGOLD	787.08	<0.05	Data is Nonnormal
8	LNCRUDE	32103.72	<0.05	Data is Nonnormal
9	LNCRYPTO7	2785.28	<0.05	Data is Nonnormal

ter should be negative whenever Rf > Ep and the Sharpe ratio generates inconsistent risk treatment (Vidal-Garcia &Vidal, 2022).

Modified Sharpe ratio (SRm) substitutes the absolute return premium. It introduces a relative premium that resolves the inconsistency related to the inadequate risk treatment in the original Sharpe ratio where (r) is risk free rate, mean (μ) and standard deviation (σ) are sample estimates. (Vidal-Garcia &Vidal, 2022). The expression is explained in the following:

$$SR = \frac{\mu / r}{\sigma}. \tag{10}$$

Now, one can find the partial derivative of the alternative ratio compared to its risk, and it becomes no longer necessary that fund returns exceed the risk-free asset to avoid an inappropriate risk treatment.

$$\frac{\delta SRm}{\delta \sigma} = \frac{-\mu / r}{\sigma_p^2}. \tag{11}$$

Since the Modified Sharpe ratio can make a more precise adjustment of profitability with the volatility assumed, it becomes a better measure of profitability. The current study uses a modified Sharpe ratio and an adjusted Sharpe ratio to measure portfolio performance.

Value at Risk (*VaR*) is the process of quantifying the risk of adverse price movements. It provides the maximum potential portfolio loss amount that will not exceed over a given time horizon with a small probability (Jorion, 2007). Thus, if the random variable *X* describes potential portfolio profits and losses with the related quantile x_A, then A will represent the percentage of worst cases considered, i.e.

$$\alpha = A\% = \epsilon(0,1). \tag{12}$$

In this case, the supreme of the worst cases percentage *α* will be considered the *VaR*.

$$VaRa = -xA(X) = \\ = -\sup\{x \mid P[X \le x] < \alpha\} \tag{13}$$

It is neither sub-additive nor coherent as a measure of risk (Artzner et al., 1999). The mandate of the expected shortfall has been introduced and mandated by the regulatory authorities (Burdorf & Van Vuuren, 2018). So, the value of maximum shortfall has emerged as an essential risk metric. Modified *VaR* estimates the tail conditional expectation and calculates the maximum shortfall expected shortfall. (i.e., the average of losses greater than the *VaR* at a significance level).

When the value at risk adjusts, the risk is measured by volatility alone, along with skewness and kurtosis of the distribution. This helps to measure the risk of a multi asset portfolio with non-normally distributed assets and solve the portfolio optimization process by minimizing the modified value at risk at a given confidence level (Favre & Galeano, 2002). In the current study, the portfolio performance of the Optimal Risky Portfolio, Naïve Portfolio, and Equal Risk Contribution Portfolio is measured by the adjusted Sharpe ratio, modified Sharpe ratio, and measurement of extreme shortfall in a portfolio using the modified value at risk method. The authors compare the performance of the three portfolios created using the metrics with the MSCI Index and S&P500.

3. RESULTS

From January 2018 to March 2020 (Pre Covid-19), most assets realized daily negative mean returns. Gold was the least volatile asset class, with a 0.83 % standard deviation. (Table 3). Gold diversifies portfolios but is not a core investment. Gold provided the best risk-adjusted returns when the MSCI emerging Index and S&P 500 stock market had negative daily means but a greater standard deviation. The kurtosis of all assets showed that Gold had the lowest skewness at 0.57 and the minimal tail risk event. Before COVID-19, when the 10-year U.S. Treasury yield averaged 2.42% p.a. (Table 4), the optimal risky portfolios had the highest Adjusted Sharpe ratio (ASR) at 0.364 (Table 7) and modified Sharpe ratio (MSR) at 0.09 (Table 8). All other portfolios, Naïve and Equal risk, had larger negative adjusted and modified Sharpe ratios than the S&P500. During this pre-COVID-19 period, the MSCI emerging market stock index had the weakest performance and the worst negative adjusted and modified Sharpe ratio. The adjusted value at risk and severe deficit

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Table 3. Extract of descriptive statistics

Assets	B	R	I	C	S	EMB	GOLD	OIL	CRYTPO7	MSCI	S&P500
Pre COVID-19											
Mean	–0.01%	0.01%	–0.02%	–0.04%	–0.08%	–0.04%	0.03%	–0.24%	–0.06%	–0.09%	–0.03%
S.D.	1.99%	1.19%	1.22%	1.41%	1.36%	0.89%	0.83%	2.91%	19.99%	1.20%	1.50%
Kurt.	20.74	14.26	14.83	9.06	12.31	102.78	7.37	26.55	2.53	7.83	21.80
Skew.	–1.89	–2.35	–1.28	–1.06	–2.00	–8.69	–0.57	–3.14	0.58	–1.79	–2.29
COVID-19											
Mean	0.30%	0.25%	0.32%	0.16%	0.30%	0.15%	0.10%	0.51%	1.11%	0.32%	0.25%
S.D.	1.93%	1.57%	1.82%	1.22%	1.69%	0.79%	1.28%	5.63%	25.27%	1.44%	1.63%
Kurt	2.80	4.58	3.94	2.68	3.31	7.26	2.27	14.27	3.09	3.44	5.93
Skew	0.44	0.79	0.43	0.48	0.69	1.62	–0.36	0.69	0.81	0.14	0.86
Post COVID-19											
Mean	0.06%	0.07%	0.14%	0.01%	0.10%	0.00%	–0.02%	0.27%	0.19%	0.04%	0.10%
S.D.	1.36%	1.29%	1.13%	0.99%	1.16%	0.46%	1.01%	2.32%	27.63%	1.01%	0.96%
Kurt	0.82	4.40	3.26	0.61	1.36	3.75	3.26	4.00	13.11	1.48	1.98
Skew	–0.14	–1.06	0.20	0.05	–0.18	0.15	–0.96	–0.74	0.37	0.09	0.12
Post COVID-19 Out of sample											
Mean	0.00%	–0.37%	0.01%	–0.03%	–0.06%	–0.15%	–0.01%	0.08%	–0.14%	–0.15%	–0.06%
S.D.	1.22%	4.66%	1.32%	1.23%	1.38%	1.07%	0.89%	3.33%	24.61%	1.22%	1.60%
Kurt	2.06	46.76	3.39	5.94	0.66	1.56	2.71	9.94	0.86	0.86	0.45
Skew	0.20	–4.83	0.08	–1.60	–0.25	–0.60	0.44	1.01	0.00	–0.47	–0.35
Russo Ukraine											
Mean	–0.03%	–0.19%	0.01%	–0.01%	0.02%	–0.08%	0.01%	–0.02%	–0.22%	–0.09%	–0.06%
S.D.	1.38%	3.51%	1.09%	1.07%	1.32%	1.04%	0.91%	2.93%	24.14%	1.20%	1.48%
Kurt	1.63	74.30	4.17	5.67	1.41	2.14	1.94	8.70	0.54	1.45	0.87
Skew	–0.03	–5.87	0.10	–1.13	0.15	0.07	0.38	0.85	0.29	0.05	–0.04
Russo-Ukraine out of sample											
Mean	0.19%	0.28%	0.09%	–0.04%	0.00%	–0.02%	0.09%	–0.20%	–0.69%	0.04%	–0.15%
S.D.	1.16%	0.99%	0.62%	0.77%	1.02%	0.48%	1.06%	2.32%	22.30%	0.78%	0.91%
Kurt	1.48	0.80	0.37	0.34	0.38	0.31	0.15	0.24	–0.04	0.17	–0.39
Skew	0.43	0.48	–0.05	0.01	–0.11	–0.49	0.09	–0.16	0.26	0.05	0.06

in a $100 million portfolio show that the S&P 500 had the biggest shortfall. A 100 million S&P 500 portfolio pre-COVID-19 would be 89.29 million (Table 9) with 99% certainty. The optimal risky portfolio is anticipated to be 96.46 million simultaneously with 99% certainty.

During the COVID-19 phase, all financial markets were tumultuous from March 24 through September 29, 2020. The authors examined 30% of the pre-COVID era, including the COVID-19 pandemic peak. From 19/03/2020 – 18/02/2021, Brent Crude, Sensex, and Cryptocurrencies had the highest daily gains at 0.51%, 0.32%, and 1.11%, respectively (Table 3). Crypto7 Index's highest daily standard deviation was 25.27%. The Emerging Market bond ETF, Gold, and MSCI emerging Index had the lowest standard deviation or risk. As COVID-19 spread, global financial markets were unsettled, and the 10-year Treasury rate hovered around 0.79% (Table 4).

Table 4. Yield of 10-year U.S. Treasury bond

Source: www.investing.com

Period	Risk-free Rate
Pre COVID	2.42%
COVID (Pre COVID out of sample)	0.79%
Post COVID	1.35%
Post COVID out sample	2.66%
Russo-Ukraine War	3.15%
Russo-Ukraine war (out of sample)	3.60%

The optimal risky portfolio had the best ASR of 4.849 (Table 7) and MSR of 2.18 (Table 8). The MSCI Index had the second-best ASR, with 3.508. The Equal Risk portfolio has the second-highest adjusted Sharpe ratio, behind the ideal risky portfolio at 1.25 (Table 8). Conversely, the Naïve portfolio creation approach had the lowest ASR, and the S&P500 had the lowest MSR. The 100 million Naïve Portfolio, closely followed by the S&P 500 at 95.69, saw a significant deficiency (Table 9). With the lowest 100 million portfolio gap, the Optimal

Table 5. Recommended optimal risky portfolios

Period	Weights of Assets								
	B	R	I	C	S	EMB	Gold	OIL	CRYPTO7
Pre COVID	0%	0%	0%	0%	0%	0%	100%	0%	0%
COVID (Pre covid out of sample)	0%	1%	18%	12%	15%	45%	5%	4%	1%
Post COVID	0%	0%	57%	0%	16%	0%	0%	26%	0%
Post COVID out sample	0%	0%	0%	0%	0%	0%	0%	100%	0%
Russo Ukraine War	0%	0%	0%	0%	100%	0%	0%	0%	0%
Russo-Ukraine war (out of sample)	22%	39%	16%	0%	0%	0%	23%	0%	0%

Risky portfolio continued to excel. This portfolio has 98.42, a smaller gap than pre-Covid (19 times at 96.42).

The period 30/09/2020 – 31/01/2021(ost Covid-19) overlaps with the Out of Sample of pre-COVID-19, so asset risk and return patterns were similar. Brent Crude had the highest daily returns of 0.27% (Table 3), followed by cryptocurrencies at 0.19% and Sensex at 0.14%. Cryptocurrency has the highest standard deviation at 27.63% and a high kurtosis, indicating a 13.11 tail risk. Thus, it did not qualify for the ideal risky portfolio due to its low risk-adjusted return. The U.S. 10-year Treasury rate rose to 1.35% p.a. during the second and third waves and the appearance of many COVID variations as the global economy recovered. The optimal portfolio creation approach again had the greatest ASR of 2.459 (Table 7), followed by the S&P 500 at 1.59. The former had the greatest MSR at 0.77 (Table 8), slightly higher than the S&P 500's 0.61 modified Sharpe ratio, and the S&P Index followed suit.

Russia invaded Ukraine on February 24, 2022. In the Post-Covid Out-of Sample Period from February 1, 2022, to August 25, 2022, Brent Crude delivered the highest mean return, averaging 0.08% and a standard deviation of 3.33%. (Table 3). Crude oil, with a kurtosis of 9.94, indicated a substantial tail risk. Cryptocurrencies had the best returns at 0.14% but the highest standard deviation at 24.61%. The 10-year Treasury yield reached 2.66% (Table 4). All three portfolio creation metrics increased Sharpe ratios throughout this era. After the Russian invasion of Ukraine, the world accepted COVID-19 as normal. The optimal portfolio creation strategy has the highest Sharpe ratio. However, the ASR was 0.354, while the other two portfolio techniques exhibited negative ASR and MSR (Tables 7 and 8). MSR included tail risk and was a meagre 0.10 for the optimal risky portfolio. The MSCI emerging equities index had the lowest adjusted and modified Sharpe ratios at –2.183 and -0.74, followed by the S&P Index.

The Russian invasion of Ukraine caused asset price volatility, especially in crude oil and Moex. From 01/02/2022 – 28/02/2023, Moex delivered daily mean returns of -0.19% with a standard deviation of 3.51% (Table 3) and a very high tail risk (kurtosis at 74.30). Brent Crude oil prices were tracked with daily mean returns of -0.02%, a standard deviation of 2.93%, and a kurtosis of 8.70. This volatility in Crude oil prices affected the Sharpe Ratios negatively. Thus, the optimal risky portfolio, which suggested 100% crude oil exposure in the past, now recommends 100% South African Index – STOP 40. STOP 40 had daily mean returns of 0.02%, a low standard deviation of 1.32%, and a low kurtosis of 1.41, unlike Crude, Moex, and the Chinese Index (SSE). Zero risk weightage

Table 6. Recommended equal risk contribution portfolios

Period	Weights of Assets								
	B	R	I	C	S	EMB	Gold	OIL	CRYPTO7
Pre COVID	33%	21%	0%	0%	19%	0%	0%	23%	4%
COVID (Pre covid out of sample)	46%	8%	7%	5%	7%	4%	4%	16%	4%
Post COVID	72%	0%	0%	0%	0%	0%	0%	24%	4%
Post COVID out sample	49%	22%	0%	0%	0%	0%	0%	24%	4%
Russo Ukraine War	11%	0%	21%	26%	0%	18%	25%	0%	0%
Russo-Ukraine war (out of sample)	62%	0%	0%	0%	0%	0%	0%	34%	4%

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Table 7. Portfolio evaluation as per Adjusted Sharpe Ratio

Adjusted Sharpe ratio (Annualized)	Optimal	Naïve	Equal Risk	MSCI Index	S&P500
Pre COVID-19	0.364	–0.404	–0.905	–1.341	–0.392
COVID (Pre covid out of sample)	4.849	1.902	3.132	3.508	2.449
Post COVID-9	2.459	0.448	1.118	0.518	1.594
Post COVID-19 sample	0.354	–0.491	–0.682	–2.183	–0.749
Russo-Ukraine War	0.084	–0.936	–0.839	–1.415	–0.730
Russo-Ukraine war (out of sample)	5.778	–0.309	0.078	0.620	–2.830

Table 8. Portfolio evaluation as per Modified Sharpe Ratio

Modified Sharpe ratio (annualized)	Optimal	Naïve	Equal Risk	MSCI Index	S&P500
Pre COVID	0.09	–0.151	–0.16	–0.30	–0.05
COVID (Pre COVID out of sample)	2.18	0.98	1.39	1.25	0.91
Post COVID	0.77	0.09	0.32	0.20	0.61
Post COVID out sample	0.10	–0.18	–0.20	–0.74	–0.28
Russo Ukraine War	0.03	–0.20	–0.30	–0.52	–0.28
Russo-Ukraine war (out of sample)	2.96	–0.15	0.03	0.27	–1.20

in an equal risk contribution portfolio included the South African Index STOP 40's risk. The Optimal risky portfolio has the greatest risk-adjusted Sharpe ratio of 0.084 (Table 7). The Naïve Portfolio and Equal Risk Contribution Portfolio had negative Sharpe Ratios throughout the same time. The MSCI index had the worst ASR at –1.415. S&P500 had a –0.730 ASR. The MSR and risk-adjusted returns ranked similarly.

In the post-Russian invasion of Ukraine Out-of-Sample Period: 01/03/2023 – 14/06/2023, the U.S. 10-year Treasury yield peaked at 3.6% a year after the invasion of Ukraine by Russia owing to rising bond rates. All assets except Brent Crude and Cryptocurrencies had a standard deviation of 0.06% to 1.16% (Table 3). The ideal risky portfolio weighted Moex 39%, Bovespa 22%, Sensex 16%, and Gold 23% (Table 5). Gold's glitter returned to an optimal risky portfolio, as seen in the pre-COVID period. The equal risk contribution portfolio's only risky assets are Bovespa at 62% (see Table 6) and Brent Crude at 34%. The optimal risky portfolio design strategy again produced the greatest ASR of 5.778 (Table 7), compared to the S&P 500's -2.830 and the MSCI emerging market index's 0.620. Similar outcomes were seen with MSR-based portfolios. The ideal portfolio to the worst MSR had a ratio of 2.96 (Table 8), followed by the MSCI Emerging Equity Index and S&P 500 at –1.20.

4. DISCUSSION

Rajput and Sufiya (2022) found cointegration in the BRICS indices, implying overseas investors had few diversification benefits. On the contrary, the current research found evidence supporting the inclusion of BRICS indices in multi asset portfolios in the different sub-periods investigated in the study.

In the Pre-COVID Period: 3/01/2018 – 18/03/2020, the Optimal Portfolio had the best ASR and MSR and the lowest deficit in a 100 million portfolio, as

Table 9. Portfolio evaluation as expected shortfall using modified Value at Risk (MVaR)

Value of a 100 million portfolio	Optimal	Naïve	Equal Risk	MSCI Index	S&P500
Pre COVID	96.46	93.69	91.64	94.79	89.29
COVID (Pre COVID out of sample)	98.42	94.27	96.14	95.98	95.69
Post COVID	96.62	84.48	94.45	97.42	97.50
Post COVID out sample	88.34	92.55	94.03	96.45	95.71
Russo-Ukraine War	96.68	95.99	98.46	96.75	96.16
Russo-Ukraine war (out of sample)	99.05	94.88	96.47	98.24	97.87

Note: At 99% confidence interval.

measured by the modified Value at Risk (mVaR) approach during the pre-COVID-19 sub-period. The MSCI Emerging Market Index had the lowest Sharpe ratios, and the S&P 500 had the most significant shortfall in a $100 million portfolio. The analysis contradicts Jeribi et al. (2021), who found that cryptocurrencies protected BRICS markets before the COVID-19 epidemic. The present study suggests that an optimal risky portfolio should not include cryptocurrency during the crisis period of COVID-19. The current research paper findings found results in contrast to past studies of Jeribi et al. (2021), Batista and Alves (2021), Justkaite and Gudelyte-Zilinskiene (2022), and Koziuk (2022).

Gold is considered a safe investment (Bredin et al., 2015; Dong, 2021). Ren et al. (2022) found that the COVID-19 pandemic reduced the usefulness of Gold as a diversification tool. Gold received a 100% weight during the pre-COVID-19 period; however, it received a very low weight in the pre-COVID out-of-sample period. The authors analyze a similar pattern during the Out of Sample following pre-COVID-19. In the COVID-19 (Out of Sample of Pre-COVID-19) Period: 19/03/2020 – 18/02/202021, the ideal risky portfolio allocates 45% to the Emerging market bond Index, 18% to the Indian Sensex, 15% to the South African STOP 40 Index, and 12% to the Chinese Index. The allocation to Gold and Crude was cut to 5% and 4%. This matches the results of the study of Dong et al. (2021), who found that Gold's hedging qualities changed before and throughout the COVID-19 pandemic. Ren et al. (2022) found that Gold's hedging properties declined during the COVID-19 pandemic.

In the post-COVID period from 30/09/2020 to 31/01/2021, the naïve portfolio building strategy has the lowest adjusted and modified Sharpe ratio. A 100 million S&P500 portfolio dropped to 97.50 post-COVID-19. The MSCI Emerging Market Index fell to 97.42 shortly after. The optimal risky portfolio was more volatile than the benchmark indices, as the former had its exposure to multiple countries and assets. The Naïve portfolio experienced the most significant expected loss in value at 84.48. The Value of Risk performance of the Naïve portfolio was the worst among the six periods evaluated. In the Post-Covid Out-of-Sample Period from February 1, 2022, to August 25, 2022, the MSCI Emerging Market Index has the lowest Sharpe Ratio. The optimal risky portfolio, 100% Brent oil, lost the greatest value within this period. At 99% certainty, the ideal 100 million portfolio dropped to 88.34 million. The MSCI emerging market index had the lowest expected shortfall value in a 100 million portfolio (Table 9). This conclusion supports Wang et al. (2019), who found a strong link between BRICS equity markets and oil markets under severe situations. The optimal risky portfolio showed that crude oil optimizes the Sharpe Ratio the most.

In the Russian invasion of Ukraine war Period from 01/02/2022 to 28/02/2023, the optimal risky portfolio had the greatest MSR of 0.03, as seen in Table 8. The emerging Index had the worst Minimum Sharpe Ratio (MSR) of –0.52, while the equal risk portfolio had -0.30. The S&P 500 and Naïve portfolio had MSR values of –0.28 and –0.20, respectively. At a 99% confidence level, most portfolios, the MSCI emerging stocks index, and the S&P 500 had a large decline in portfolio value over this period. Table 9 shows a 96 million shortage for a 100 million portfolio. Only the equal risk portfolio performed better in Value at Risk (VaR) in this period. The portfolio's value dropped to 98.46 as the significant shortfall decreased. In the Post-war period led by Russia on the Ukraine War Out-of-Sample Period: 01/03/2023 – 14/06/2023, the optimal risky portfolio has the greatest projected shortfall metric value of 99.05 (Table 9) for a 100 million portfolio valued at 99%. The developing market equities portfolio performed 98.24, while the S&P 500 performed 97.87. The worst-performing portfolio was Naïve, valued at 94.88 million.

CONCLUSION

This research paper constructs and investigates multi asset portfolios using three portfolio construction strategies: BRICS equities, Gold, Crude oil, bonds, and cryptocurrencies from January 2018 to June 2023, outperforming the S&P500 and MSCI Index for three periods. The authors validated their findings using various optimization methodologies, including the Optimal Risky Portfolio, Naïve Portfolio, and Equal

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Risk Contribution Portfolio. The validations occurred during the pre-COVID-19 crisis, post-COVID-19, and the Russian invasion of Ukraine and subsequent wars led by the former. The portfolios outperformed the Naïve portfolio, an equal risk contribution portfolio, the MSCI Index, and the S&P 500 in terms of adjusted Sharpe ratios and modified ratios. The researchers also evaluated the results using the adjusted Sharpe ratio, modified Sharpe ratio, and extreme portfolio value shortfall. This study aims to demonstrate the benefits of portfolio diversity using BRICS indices, Gold, Brent crude oil futures, and the supremacy of the traditional optimal risky portfolio technique in creating international multi asset portfolios.

The optimal risky portfolio outperforms the portfolio's expected shortfall in value throughout the analyzed periods, except for two out-of-sample periods: the COVID-19 period from March 2020 to February 2021 (used as the pre-COVID-19 period) and the post-sample period from February 2022 to August 2022.

Based on the ASR evaluation metric, the MSCI emerging stock index performed worse during the pre-COVID-19, post-COVID-19 out-of-sample, and Russian invasion of Ukraine and the subsequent war, the S&P 500 performed worst in the year after Russia invaded Ukraine. This phenomenon can also be attributed to the 10-year government bond yield rising to 3.60% annually during the research, and during and after COVID-19, the Naïve portfolio had the lowest Average Sharpe Ratio (ASR).

In the entire research period, the portfolio that used an equal risk contribution method did not perform optimally according to risk-adjusted metrics – ASR and MSR. The MSCI developing index had the worst Modified Sharpe Ratio (MSR). Underperformances were notable in the weeks before the COVID-19 epidemic. The MSCI emerging market Index had the least MSR post-COVID-19 and during the Russian invasion of Ukraine. After the COVID-19 pandemic, the Naïve portfolio had the MSR. The COVID-19 pandemic and the year after the Russia-led war against Ukraine caused the S&P 500 index's biggest market stress reaction. The S&P 500 underperformed in all three stages, while the Naïve portfolio underperformed throughout the COVID-19 and post-COVID-19 eras.

The value deficit of a $100 million portfolio must be estimated using modified Value at Risk (mVaR) ideas. The S&P 500 performed poorly on this criterion before the COVID-19 pandemic. Scarcity increased during the COVID-19 epidemic and the Russian invasion of Ukraine. The Naïve portfolio had the lowest mVAR performance during four phases: COVID-19, post-COVID-19, Russian invasion of Ukraine, and Out-of-sample Russo-Ukraine war. The minimum value at risk (mVaR) measure showed that the equal risk portfolio and MSCI Emerging Markets Index performed below ideal levels, except during the Russia-led war on Ukraine and the post-COVID-19 out-of-sample period.

In conclusion, the naïve and equal risk portfolios performed poorly during economic downturns, as measured by performance criteria such as adjusted risk-return and value at risk. The academic literature has focused on Optimal Risky portfolio construction. The optimal risky portfolio's supremacy over the MSCI emerging market Index and S&P 500 portfolios is crucial.

The discovery in this work advances the knowledge frontier. Gold outperformed other investments in the year before COVID-19. BRICS equities performed well during the COVID-19 pandemic. After the COVID-19 pandemic and the Russian-led war against Ukraine, Brent crude oil helped boost risk-adjusted profits. Gold's influence on India, Russia, and Brazil's equity indices shows it is again a viable asset for diversifying international investment portfolios after months of the Russo-Ukraine war and crisis.

In the turbulent COVID-19 era, this analysis shows that Emerging Market Bonds ETF provided diversification. Cryptocurrencies failed to optimize multi asset portfolios during the period of study. One exciting area of future opportunity research could be measuring portfolio performance and hedging approaches using risk-adjusted return measurements, including transaction expenses and dynamic rebalancing techniques.

AUTHOR CONTRIBUTIONS

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Formal analysis: Nupur Gupta, Pradip Mitra.
Investigation: Nupur Gupta, Pradip Mitra.
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