UNIVERSITÀ DEGLI STUDI DI BARI ALDO MORO

DIPARTIMENTO JONICO IN SISTEMI GIURIDICI ED ECONOMICI DEL MEDITERRANEO SOCIETÀ, AMBIENTE, CULTURE
IONIAN DEPARTMENT OF LAW, ECONOMICS AND ENVIRONMENT

19
2022

QUADERNI DEL DIPARTIMENTO JONICO

SYSTEMIC RISK, MONETARY POLICY AND PORTFOLIO DIVERSIFICATION IN THE GREAT CRISES' ERA

edited by
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EDIZIONI DJSGE

ISBN: 9788894503098

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dell’Università degli Studi di Bari Aldo Moro
ha chiuso il volume, composto da 109 pagine, il 17 Giugno 2022.
Il testo è disponibile open source sul sito
https://www.uniba.it/ricerca/dipartimenti/sistemi-giuridici-ed-economici/edizioni digitali

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SUKUK AND GREEN BONDS' ROLE IN GLOBAL MACRO PORTFOLIO DIVERSIFICATION: EVIDENCE FROM COVID-19 CRISIS*

ABSTRACT

La crisi di Covid-19 ha risvegliato e rafforzato alcuni temi di tendenza legati alla gestione del rischio di portafoglio e alla mitigazione del rischio sistemico. I principali gestori di portafoglio hanno iniziato a testare nuove strategie flessibili di tipo *multi-asset* (anche dette strategie Global Macro) basate sull'interpretazione di condizioni macroeconomiche di ampia portata. Queste strategie prevedono, nella costruzione dell'*asset allocation*, l'utilizzo di posizioni lunghe e corte in azioni, obbligazioni, materie prime, ecc. Questo lavoro vuole testare il contributo corretto per il rischio dei Sukuk (obbligazioni islamiche) e dei Green Bond come strumenti alternativi agli strumenti di reddito fisso convenzionali, considerando il periodo pre e post Covid-19. L'asset allocation è stata progettata seguendo i fondamenti del Global Macro e risolvendo un problema di ottimizzazione *risk-parity* utilizzando un algoritmo MATLAB™ appositamente sviluppato. I risultati forniranno approfondimenti sul potere di copertura e di rifugio dei Sukuk e dei Green Bond, contribuendo all'ampliamento della letteratura sulla gestione del rischio di portafoglio e allo sviluppo di un'asset allocation alternativa funzionale ai fondamenti del Global Macro.

Covid-19 distress has awakened and reinforced some long-standing trending topics related to portfolio risk management and systemic risk mitigation. Portfolio managers have started to test flexible multi-asset portfolio strategies (Global Macro Strategies) based on the interpretation of large macroeconomic conditions, including the asset allocations of long and short positions in equities, bonds, commodities, etc. This study aims to test the risk-adjusted contribution of Sukuk (Islamic bonds) and Green Bonds as alternative instruments compared to conventional fixed-income, covering the last Covid-19 crisis. The asset allocation is designed following the fundamentals of Global Macro and solving a risk-parity optimisation problem using a specifically developed MATLAB™ algorithm. The findings will provide insights into the testing hedge and safe-haven power of Sukuk and Green Bonds, contributing to the widening literature on portfolio risk management and developing an alternative asset allocation functional with Global Macro fundamentals.

KEYWORDS

Portfolio Management – Sustainable Finance – Islamic Finance

SUMMARY: 1. Introduction and Background. – 2. Methodology: the Risk Parity Optimization Problem. - 3. Data and Sample Selection. – 4. Empirical Results: Descriptive Statistics and Correlations

* Paper audited according to the system for *peer review*

– 5. Empirical Results: The Conventional GM Portfolio ERC Optimisation - 6. Empirical Results: The *Alternative GM Portfolio* ERC Optimisation - 7. Conclusions and Further Remark

1. The impact of Covid-19 and change in macroeconomic scenario is felt beyond the health sector and severely affected stocks and the whole financial markets more generally. Morgan Stanley Outlook in 2021 has predicted the overheating of the economy *"as economic imbalances wrought by the pandemic begin to ease, investors could be in for hotter-than-expected growth and inflation"*[1]. The vulnerability of financial markets, due to firms' squeezing profits, credit crunch, energy crisis, and geopolitical and economic uncertainty, the vulnerability of financial markets contribute to increased systemic risk. According to So et al. in 2022[2], systemic risk in financial markets may occur due to a simultaneous fall in the price of most or all stocks in the market caused by an event affecting one or more company or business sectors. Financial system globalisation and interconnection have emphasised this phenomenon, facilitating systemic risk propagation. In this evolving scenario and increasing challenges, investors and portfolio managers have renewed their attention to alternative investments, which could offer significant diversification for the conventional markets and portfolios severely affected by this uncertainty, trying to reduce the systemic risk sword of Damocles[3].

For more than ten years, the world's stock markets have seen record growth since the world's major central banks have jointly exercised unprecedented expansionary monetary policy producing record-low bond yields and record-high equity prices, almost forgetting portfolio risks and volatility. During these calm periods, investors allocate more to stocks and high volatility assets to achieve higher returns and switch to fixed-income asset classes during turbulent markets to reduce their portfolio aggregate risk. Thus, as in any financial downturns or market stress, as for the Covid-19 crisis, investors and asset managers are looking for uncorrelated or negatively correlated assets or portfolio strategies, which could provide safe-haven power and hedging benefits, risk-diversification, and maximum drawdown mitigation. In this regard, academics and practitioners have recently started showing particular interest in sustainable and ethical finance, green investments and non-conventional markets such as the Islamic Financial one[4]. During these times occurs a renewed attention to alternative strategies that fit with the "Global Macro" description. Global Macro is a flexible multi-asset portfolio strategy based on the interpretation of large

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[1] See Morgan Stanley. (2020). *2021 Global Strategy Outlook: Keep Faith in the Recovery*.
[2] See So, M.K.P., Mak, A.S.W., Chu, A.M.Y. (2022). *Assessing systemic risk in financial markets using dynamic topic networks. Sci Rep 12, 2668.*
[3] See Naeem, M.A., Rabbani, M.R., Karim, S., Billah, S.M. (2021). *Religion vs ethics: hedge and safe haven properties of Sukuk and green bonds for stock markets pre- and during COVID-19.*
[4] See Yarovaya, L., Elsayed, A.H. (2021). *Determinants of spillovers between islamic and conventional financial markets: exploring the safe haven assets during the COVID-19 pandemic*, *Finance Research Letters, 43.*

macroeconomic conditions, mainly adopted by hedge fund managers. These strategies include the asset allocations of long and short positions in equities, bonds, commodities, currencies etc. Global Macro generally has outperformed other strategies, resulting in positive returns than other strategies that have been severely challenged[5]. Notably, it benefits from sustained increased volatility in currencies, interest rates, commodities and equities, and it has a low correlation to stocks. These reasons fit together with boundary conditions that occur during crisis periods.

Looking at the mentioned alternative asset classes, literature provides evidence about green bonds' diversification power and hedge capability under unfavourable market circumstances[6]. Green bonds are similar to conventional bonds, and they are used to finance environmentally friendly and green projects satisfying the demand for clean and renewable energy[7]. Similarly, Sukuk, also called Islamic Bond, Islamic Stock or Islamic debt securities, is an Islamic Financial instrument with similar properties to conventional bonds. It is based on the asset-backed rules of securitisation or conventional covered bond s*hariah* compliant Sukuk can offer diversification opportunities to conventional portfolios since they have a low correlation with conventional bonds, particularly during turmoil periods[8]. Thus, the question is related to the possibility of integrating the fixed-income component of the asset allocation with these alternative instruments.

Finally, this paper contributes to the literature on portfolio systemic risk management, examining the hedge and safe-haven properties of alternative asset classes such as Sukuk and green bonds for the conventional portfolio strategies during financial market turmoil as in the Covid-19 crisis. According to the literature previously mentioned, investors use the strategy of hedging and diversification to combat the adverse impact of the stock market downturn on their investment portfolios, trying to mitigate the systemic risk associated with exogenous events such as Covid-19. Notably, this paper does not seek to merely explore the best strategies or financial assets performing during market crises. Following the integration approach, Delle Foglie and Panetta[9] proposed, this paper aims to consider the possibility of including alternative asset classes to the conventional portfolio allocation to increase diversification, mitigate risks and reduce maximum drawdown. In this way, is it possible to continue the aim of Global Macro investors, trying to build portfolios that perform well across different economic scenarios. Thus, in this paper, we build an Alternative Global Macro

[5] See Casano, J. (2010). *Global macro Hegde fund investing: an overview of the strategy*, NEPC, Boston.
[6] See Hachenberg, B., Schiereck, D. (2018). *Are green bonds priced differently from conventional bonds?, Journal of Asset Management, 19 (6).*
[7] See Naeem, M.A., Farid, S., Ferrer, R. and Shahzad, S.J.H. (2021). *Comparative efficiency of green and conventional bonds pre-and during COVID-19: an asymmetric multifractal detrended fluctuation analysis*, *Energy Policy, 153.*
[8] See Paltrinieri, A., Hassan, M.K., Bahoo, S., Khanc, A.(2019).*A bibliometric review of sukuk literature*.
[9] See Delle Foglie, A., Panetta, I.C. (2020). *Islamic stock market versus conventional: Are islamic investing a 'Safe Haven' for investors? A systematic literature review*.

(GM) Portfolio and test its risk-adjusted performance compared with a conventional Global Macro strategy. To build the asset allocation, this paper follows the literature strands concerning the Risk Parity model[10] [11] [12], often used by fund managers as an asset allocation selection criteria.

The remainder of this paper is organised as follows. Section 2 provides the research design, focusing on empirical properties of the risk parity heuristic approach. The optimisation problem of the risk parity is solved using the specifically designed MATLAB algorithm. Section 3 presents and debates the data, and Sections 4, 5 and 6 present descriptive statistics, correlations and empirical results of the conventional and alternative portfolio. Finally, the main conclusions and further remarks are disclosed in Section 7.

2. The development of risk parity and risk budgeting techniques has marked an important milestone in portfolio risk management, rewriting Markovitz's Modern Portfolio Theory and changing market players' mindsets[13]. In addition, after the dark years (2008-2011) and various market stresses in recent years (2015-2016 Stock Market Sell-Off, or Covid-19 Market Crash), the Equal Risk Contribution (ERC) has been very popular and significantly impacted the asset management industry. For instance, in 2011, Bridgewater Associates, the world's biggest hedge fund company, has first opened the doors to this strategy by publishing a famous milestone paper, "Risk Parity is about balance", imaging *"to design a portfolio based on a fundamental understanding of the environmental sensitivities inherent in the pricing structure of asset classes"*[14]. The risk parity approach in ERC seems to provide stability to the asset allocation since it does not consider any returns in the weight distribution but the risk contribution of a single component as the Marginal Risk Contribution (a share of the total portfolio risk contribution). Thus, it appears more robust than the *Markovitzian*

[10] See Quian, E. (2005) *Risk Parity Portfolios: Efficient Portfolios through True Diversification, Panagora Asset Management, Boston.*
[11] See Lee, T., Spellar, A., Bouchey, P. (2013).*Understanding Risk Parity – The Clifton Group, Division of Parametric Portfolio Associates.*
[12] See Roncalli, T. (2013). *Introduction to Risk Parity and Budgeting*.
[13] G.C. Hallen, *The Risk Parity Approach to Asset Allocation*, Callan Investment Research Institute, 2010.
[14] Bridgewater Associates, *Risk Parity is about balance*, White Paper Bridgewater Ass, 2011.

mean-variance optimised portfolios[15 16 17 18 19 20 21 22 23 24]. According to Richard and Roncalli (2019), we defined a portfolio *X = (x1; x2; …; xn)* of n risky assets, assuming no possibility of leverage, short selling, minimum investment weight, sector neutrality or liquidity thresholds. We assume the $MRC_i(x) = \frac{(\Omega x)_t}{\sqrt{x^T\,\Omega x}}$ and the $TRC_i(x) = x_i \frac{(\Omega x)_t}{\sqrt{x^T\,\Omega x}}$, where *Ω* is the covariance matrix. Since the ERC aims to build a risk-balanced portfolio considering the asset allocation in terms of risk contribution (risk budgeting), we consider risk budget *b*, and the vector of risk in the percentage of the total risk $b = (b_1, b_2, \ldots, b_n)$, where $b_i = b_j = 1/n$, the $TRC_i(x) = TRC_j(x)$ and the $x_i \frac{(\Omega x)_t}{\sqrt{x^T\,\Omega x}} = x_j \frac{(\Omega x)_t}{\sqrt{x^T}}$ so it is easy to show that the

$$\sum_{i=1}^{n} TRC(x) = nTRC_i(x) \text{ and the } TRC_i(x) = \frac{\sigma(x)}{n}. \quad (1)$$

In order to find the solution, the risk parity can be solved as the following optimisation problem:

$$X = arg\ min\ f(x) \quad (2)$$

$$where\ f(x) = \sum_{i=1}^{n} \sum_{i=1}^{n} (TRC_i(x) - TRC_j(x))^2$$

$$where\ f(x) = \sum_{i=1}^{n} \sum_{i=1}^{n} (x_i\ (\Omega x\ )_i\ -\ x_i\ (\ \Omega x\ )_j)^2, \sum_{i=1}^{n} x_i = 1\ and\ x \geq 0$$

Considering the Euler decomposition of the portfolio risk measure

$$X = arg\ min \sum_{i=1}^{n} (x_i\ (\ \Omega x\ )_i - \frac{\sigma_p(x)}{n})^2 \quad (3)$$

[15] J.C. Richard, T. Roncalli, *Constrained Risk Budgeting Portfolios: Theory, Algorithms, Applications & Puzzles,* 2019.
[16] M.R. Anderson, S.W. Bianchi, L. Goldberg, *Will My Risk Parity Strategy Outperform?,* Financial Analysts Journal, 2012.
[17] B. Bruder, T. Roncalli, *Managing Risk Exposures using the Risk Budgeting Approach*, 2012.
[18] Y. Choueifaty, Y. Coignard,*Toward Maximum Diversification*, The Journal of Portfolio Management, 2008.
[19] J.S. Foresti, M.E. Rush, *Risk-Focused Diversification: Utilising Leverage within Asset Allocation*, California: Wilshire Consulting, 2010.
[20] C. Levell, *Risk Parity: In the Spotlight after 50 Years*, Zagreb: General Research, NEPC, 2010.
[21] H. Lohre, U. Neugebauer, C. Zimmer, *Diversified Risk Parity Strategies for Equity Portfolio Selection*, Journal of Investing, 2012.
[22] S. Maillard, T. Roncalli, J. Teïletche, *The properties of equally weighted risk contribution portfolios*, The Journal of Portfolio Management, 2010.
[23] A. Meucci, *Risk Contributions from Generic User-defined Factors*, The Risk Magazine, 2007.
[24] A. Meucci, *Managing Diversification*, *Risk*, 2009.

Equation (3) is equivalent to solving a nonlinear equation with *n* unknown variables. In this paper, according to Delle Foglie and Pola (2021), we solved the optimisation problem using the MATLAB Optimization Toolbox™, which provides functions for finding parameters that minimise or maximise objectives while satisfying constraints. In particular, the *fmincon* functions of MATLAB provide an SQP-based nonlinear programming solver, finding the minimum of a constrained nonlinear multivariable function of a problem[25] [26]:

$$min_x\, f(x)\ such\ that$$
$$\{c(x) \leq 0\ ceq(x) = 0\ A \cdot\ x \leq b\ Aeq\ \cdot x = beq\ lb \leq x \leq ub,$$

- *b* and *beq* are vectors, *A* and *Aeq* are matrices, *c*(*x*) and *ceq*(*x*) are functions that return vectors, and *f*(*x*) is a function that returns a scalar. *f*(*x*), *c*(*x*), and *ceq*(*x*) can be nonlinear functions.
- *x*, *lb,* and *ub* can be passed as vectors or matrices.

Optimisation Toolbox™ solvers accept vectors for many arguments (*x0* as initial point, lower bounds *lb* and upper bounds *ub*) and matrices, where the matrix is an array of any size. Here are how solvers handle matrix arguments:

- Internally, solvers convert matrix arguments into vectors before processing. For example, *x0* becomes *x0(:);*
- For output, solvers reshape the solution *x* to the same size as the input *x0;*
- When *x0* is a matrix, solvers pass *x* as a matrix of the same size as *x0* to both the objective function and to any nonlinear constraint function;
- Linear Constraints take *x* in vector form, *x(:)*. In other words, a linear constraint of the form:

$A*x \leq b$ *or* $Aeq*x = beq$, where it takes *x* as a vector, not a matrix (MathWorks Inc, 2021).

Thus, the appropriate syntax for the Risk Parity optimisation problem solution is[27] [28]:

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[25] H.R. Byrd, J.C. Gilbert, J. Nocedal, *A trust region method based on interior point techniques for nonlinear programming*, Mathematical Programming, 89: 149–85, 2000.

[26] Waltz, A.Richard, J.L. Morales, J. Nocedal, D. Orban, *An interior algorithm for nonlinear optimisation that combines line search and trust region steps*, Mathematical Programming 107: 391–408, 2006.

[27] M.Giuzio, *Genetic algorithm versus classical methods in sparse index tracking,* Decisions in Economics and Finance 40: 243–56, 2017.

[28] N.S.M. Mussafi, I. Zuhaimy, *Optimum Risk-Adjusted Islamic Stock Portfolio Using the Quadratic Programming Model: An Empirical Study in Indonesia*, Journal of Asian Finance, Economics and Business 8: 839–50, 2021.

$$x = fmincon\ (fun,x0,A,b,Aeq,beq,lb,ub) \qquad \text{(Function 1)}$$

which defines a set of lower and upper bounds on the design variables in *x* so that the solution is always in the range $lb \leq x \leq ub$. The *fmincon* function solves the interior-point algorithm approach to constrained minimisation problems by default. First, Function (1) was designed to solve the optimisation problem in Equation (3). Function (1) represents the MATLAB function computed to solve the optimisation problem shown in Equation (3):

```
fun=@(x)Aeq*(((matrcov(:,:,i)*(x)/(sqrt((x')*matrcov(:,:,i)*x))).*x-
(sqrt((x')*matrcov(:,:,i)*x ))/n_asset)).^2);
```

where *MatrCov* is the variance–covariance matrix, and *n_asset* is the number of the asset classes composing the portfolio. Second, the *fmincon* was applied to Function (1) to solve the optimization problem, writing a string to find the RP portfolio weights.

```
weight_RP(:,i)=fmincon(fun, weight_EW , [] , [] , Aeq , Beq , lb , ub , [] , o).
```

3. The sample selection was designed following the Global Macro strategies fundamentals, building a flexible multi-asset portfolio which considers traditional asset classes such as equities, fixed income instruments, commodities, gold and currencies[29] and REIT, along with alternative asset classes such as Sukuk (Islamic bonds) and Green Bonds. Following Global Macro underpinnings, the asset allocation respects the assumption of Pola (2013)[30] , which assumes a strategic asset allocation based on diversification across macroeconomic scenarios. Notably, since major global indexes are quoted in USD, we also considered the geographical and currency exposure suitable for European-based investors, adding a EUR (Euro)-based bond (and green bond) component and euro-based equities such as the MSCI Europe Price Index. To facilitate the operation of the risk-parity model, we chose not to consider both assets affected by too much and too little volatility, respectively, as commodities and cash. Considering the possibility for investors to use index-tracking instruments, the conventional asset allocation includes 14 indexes with 313 weekly observations (312 weekly returns) from 1 January 2015 to 31 December 2020 (5 years) extracted from Reuters Refinitiv Eikon. Therefore, we created a rolling time window with an in-sample period of 157 weeks (from 2 January 2015 to 29 December 2017) and an out-of-sample period of 156 weeks (from 5 January 2018 to 25 December 2020). According to the aim of this paper, the rolling window allows capturing different market scenarios to test the portfolio during *normal* (2015-2019), turbulent (February-April 2020) and post-stress times (May 2020

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[29] See Delle Foglie, A., Pola, G. (2021). *Make the Best from Comparing Conventional and Islamic Asset Classes: A Design of an All-Seasons Combined Portfolio*.

[30]See Pola, G. (2013). *Diversification measures for portfolio selection, New York, NOVA publisher*.

to the end), building a good environment to test the risk-adjusted contributions of asset classes during these times understanding their behaviour. Table 1 summarises each macro-asset class and the corresponding index selected for the asset allocation.

Table 1. Sample composition.

Macro-Asset Class	Index	Code
Equities	MSCI Europe Price Index	MSCIE
	MSCI WORLD Price Index	MSCIW
	MSCI Emerging Market Price Index	MSCIEM
	S&P 500 Index	SP500
Corporate Bonds	IBoxx Eur Liquid High Yield Index	EUROCORP
	IBoxx USD Corporates Index	USCORP
	VanEck Global Fallen Angel High Yield Bond Index	FABOND
Convertible Bonds	Refinitiv Qualified Global Convertible Index	CONVBOND
Inflation-Linked Bond	IBoxx Euro Inflation-Linked Index	EUROIL
Gold	COMEX Gold Composite Commodity Future Continuation	GOLD
REIT	FTSE EPRA NAREIT Global	REIT
Islamic Bonds	Dow Jones Sukuk Index USD	DJS
Green Bonds	IBoxx Global Green Social and Sustainability Index Eur	GSSB
	Solactive Green Bond Index USD	GBSOL

4. Table 2 and Table 3 report the descriptive statistics of the weekly asset returns and the correlation between different portfolio asset classes, respectively. MSCI World and S&P 500 indexes' performances reflect the remarkable performance of the world financial markets in the last five years, recording the highest performance of the other equity indexes. Similarly, last year's monetary stimulus (quantitative easing) and central bank *zero lower bound* monetary policy have also pushed the bond market favouring convertible bonds and sub-investment grade bonds. The convertible bonds mainly demonstrated high resilience during high volatility as in March 2020 and recorded stellar performance in the last five years, giving downside protection and upside participation[31]. Fallen angels' bonds behave similarly to the convertibles. A fallen angel is typically a high yield corporate bond that has been downgraded from investment grade to sub-investment (junk) grade due to financial troubles related to its issuers. In this case, this bond pays higher returns than investment-quality bonds, but they are riskier. Over the past decade, financial markets experienced periods of rising and falling interest rates, extensive and tight credit spreads, and periods of significant

[31] See Schroders, (2021). *Individuals & families, Wealth management at Schroders.*

credit rating upgrades and downgrades. Fallen angels' bonds have historically provided outperformance relative to the broad high yield market through these different market environments due to their unique characteristics. The correlation matrix confirms the trends related to convertible and fallen angels' bonds and government and corporate bonds, which recorded a relative-positive correlation with the equity market. According to Shen and Weisberger (2021)[32] the negative stock-bond correlation recorded in the last ten years seems to be related to low and stable risk-free interest rates and inflation and changes we are experiencing between the end of 2021 and the beginning of 2022 with the inflation and interest rate rising are modifying this trend. In addition, it is also interesting to analyse the role of precious metals such as gold, which has always been considered a safe-haven asset by investors. Due to macroeconomic conditions, gold has recorded performance similar to the equity market, with an average return of 7,55% and a volatility of 14,96%. Finally, for the analysis, we underlined the performance of the Sukuk and Green Bond indexes as alternative assets to the conventional Global Macro portfolio. Both recorded poor performance in risk-adjusted returns according to their low/relative-negative correlation with the equity market.

[32] See Shen, J., Weisberger, N. (2021). *US Stock-Bond Correlation: What Are the Macroeconomic Drivers? PGIM IAS.*

Table 2. Descriptive statistics of asset returns

Notes: This table provides sample moments, Sharpe ratios, and minimum and maximum statistics of all asset classes used in the asset allocation. The evaluation period covered 313 weeks, from 2 January 2015 to 18 December 2020 (312 weekly returns). "Mean" denotes annualised time-series mean of weekly returns, while "Std.Dev." is the associated annualised standard deviation. "Skew" and "Kurt" represent the third and fourth moments, respectively, of the return distribution. "Sharpe" denotes the annualised Sharpe ratios of the respective asset classes, considering 0.125% as risk-free according to EU zero interest rates policy in recent years. "JB (p-value)" is the p-value of the Jarque–Bera statistic for testing the normality of returns.

	Mean (%)	Std. Dev. (%)	Kurt	Skew	Sharpe	Min	Max	JB (p-Value) (%)	Weekly Returns	Weekly Obs.
MSCIE	2,24	19,35	17,81	-2,02	0,11	-0,23	0,09	0.00	312	313
MSCIW	7,93	16,91	9,94	-1,23	0,46	-0,13	0,10	0.00	312	313
MSCIEM	4,56	18,35	2,91	-0,66	0,24	-0,13	0,07	0.00	312	313
SP500	10,43	17,63	10,65	-1,34	0,58	-0,16	0,11	0.00	312	313
EUROCORP	3,29	6,94	36,75	-3,14	0,46	-0,09	0,05	0.00	312	313
USCORP	5,09	6,27	42,50	-2,72	0,79	-0,08	0,06	0.00	312	313
CONVBOND	9,99	9,80	9,56	-1,20	1,01	-0,10	0,05	0.00	312	313
FABOND	8,62	7,60	27,48	-2,31	1,12	-0,09	0,06	0.00	312	313
EUROIL	2,53	4,85	15,15	-1,82	0,50	-0,05	0,02	0.00	312	313
GOLD	7,55	14,96	2,86	-0,04	0,50	-0,10	0,09	0.00	312	313
REIT	-1,01	19,39	17,18	-1,92	-0,06	-0,21	0,13	0.00	312	313
DJS	1,13	2,98	35,03	-3,98	0,34	-0,04	0,01	0.00	312	313
GSSB	2,46	6,96	9,36	-0,82	0,34	-0,06	0,05	0.00	312	313
GBSOL	3,16	4,38	2,77	-0,69	0,69	-0,03	0,02	0.00	312	313

Table 3. Correlation matrix of asset returns (02/01/2015 to 29/12/2017)

Notes: This table provides the correlation matrix for all asset classes used in asset allocation from 02/01/2015 to 29/12/2017. * and ** indicate values significantly different from 0 at the 1% and 5% level, respectively.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
MSCIE	1,00													
MSCIW	0,89**	1,00												
MSCIEM	0,79**	0,80**	1,00											
S&P500	0,78**	0,97**	0,72**	1,00										
EUROCORP	0,12*	0,18**	0,22**	0,19**	1,00									
USCORP	-0,07	-0,02	0,04	0,03	0,68**	1,00								
CONVBOND	0,14*	0,20**	0,25**	0,21**	0,71**	0,44**	1,00							
FABOND	0,03	0,08	0,14*	0,09	0,92**	0,72**	0,74**	1,00						
EUROIL	0,14*	0,19**	0,15**	0,20**	0,52**	0,49**	0,43**	0,48**	1,00					
GOLD	0,24**	0,19**	0,25**	0,14*	-0,06	-0,07	-0,04	-0,06	-0,01	1,00				
REIT	0,68**	0,73**	0,62**	0,68**	0,20**	-0,03	0,18**	0,08	0,22**	0,26**	1,00			
DJS	0,41**	0,44**	0,46**	0,41**	0,40**	0,34**	0,36**	0,34**	0,41**	0,40**	0,52**	1,00		
GSSB	0,34**	0,30**	0,30**	0,24**	0,20**	0,10	0,20**	0,14*	0,24**	0,51**	0,22**	0,59**	1,00	
GBSOL	-0,07	0,02	-0,01	0,05	0,26**	0,18**	0,14*	0,19**	0,25**	0,03	0,40**	0,44**	-0,07	1,00

5. The first portfolio optimisation starts with the Conventional GM Portfolio, considering an asset allocation based on traditional Global Macro strategies asset classes such as equities, government and corporate bonds, gold, and REIT, for 11 asset classes. According to the previous methodology, a rolling time window with an in-sample period of 157 weeks (from 2 January 2015 to 29 December 2017) and an out-of-sample period of 156 weeks (from 5 January 2018 to 25 December 2020) in order to better capture the crisis and post-crisis scenario. We applied the ERC risk-parity optimization to implement the strategy, starting from an equally weighted (EW) portfolio as an input of the function objective applied in MATLAB (*fmincon* – Function 1). The optimisation algorithm results in portfolio asset allocation based on a risk parity model called RP. To consider the weaknesses and benefits of the ERC optimisation, Table 4 and Figure 1 reports and charts the most relevant statistics, risk-adjusted indicators, and the performance of the Conventional GM Portfolio in the out-of-sample windows (w = 156). In order to better benchmark the performance of the Conventional and Alternative GM Portfolios, we add two of the world's most significant Global Macro strategy-based funds, the Amundi Funds Global Multi-Asset Conservative E2 EUR (C) and the ESG Multi-Asset BlackRock Global Fund.

According to the Global Macro strategy's fundamentals, each asset class in the asset allocation has a specific role in performing and protecting the portfolio against any macroeconomic scenario and market shock as in 2020. The Conventional GM Portfolio based on risk parity asset allocation confirms this trend by recording the best Sharpe Ratio and the best performance (2,03 and 18,07%) with a moderate level of volatility. The maximum drawdown of the portfolio is higher than Benchmark Fund 1 due to the presence of higher volatility assets in the asset allocation. In addition, looking at Table 5, it is interesting to highlight that the RP asset allocation allocated (on average) only 27,48% of the total portfolio amount into higher volatility assets, such as equities, convertible bonds and REITs. The MRCs in Table 6 confirm this trend. Notwithstanding the highest risk-adjusted performance in the RP asset allocation, the MRCs of high volatility assets settle down to 7,49% of the volatility (based on the assumption of the model that the level of the volatility is equal to the Total Risk Contribution – TRC).

Table 4. Main Performance of the Conventional GM Portfolio.

Notes: This table summarises the portfolio out-of-sample performance. "Return" denotes the annualised time-series cumulative return, while "Volatility" shows the associated annualised standard deviation, and "Sharpe Ratio" represents the annualised Sharpe ratio to measure risk-adjusted performance. The "Max Drawdown" (MDD) is the maximum observed loss from a peak to a portfolio trough before a new peak is attained. The "Calmar Ratio" is a risk-adjusted indicator that considers MDD as a risk-adjusted risk indicator. Similarly, "Sortino Ratio" is another risk-adjusted indicator. "Benchmark Fund 1" is Amundi Funds Global Multi-Asset Conservative E2 EUR (C), a global balanced mutual fund and winner of the Morningstar Fund Awards 2021, and "Benchmark Fund 2" is the ESG Multi-Asset BlackRock Global Fund, ESG screened. The cumulative return of the benchmark fund was calculated considering the weekly closing NAV. The benchmark fund was added to facilitate the reading of the results, not for a performance comparison purpose.

	EW	RP	Benchmark Fund 1	Benchmark Fund 2
Return (%)	15,31	18,07	12,87	12,78
Volatility (%)	19,3	13,04	10,45	16,33
Max Drawdown (%)	28,11	18,75	11,06	16,27
Sharpe Ratio	1,36	2,03	0,79	1,49
Sortino Ratio	0,95	1,17	1,67	1,19
Calmar Ratio (%)	20,97	31,94	41,22	29,81

Table 5. Asset marginal weight contribution – Conventional GM Portfolio (out-of-sample period).
Note: This table summarises the asset weight contribution to the total portfolio resulting after the optimisation process.

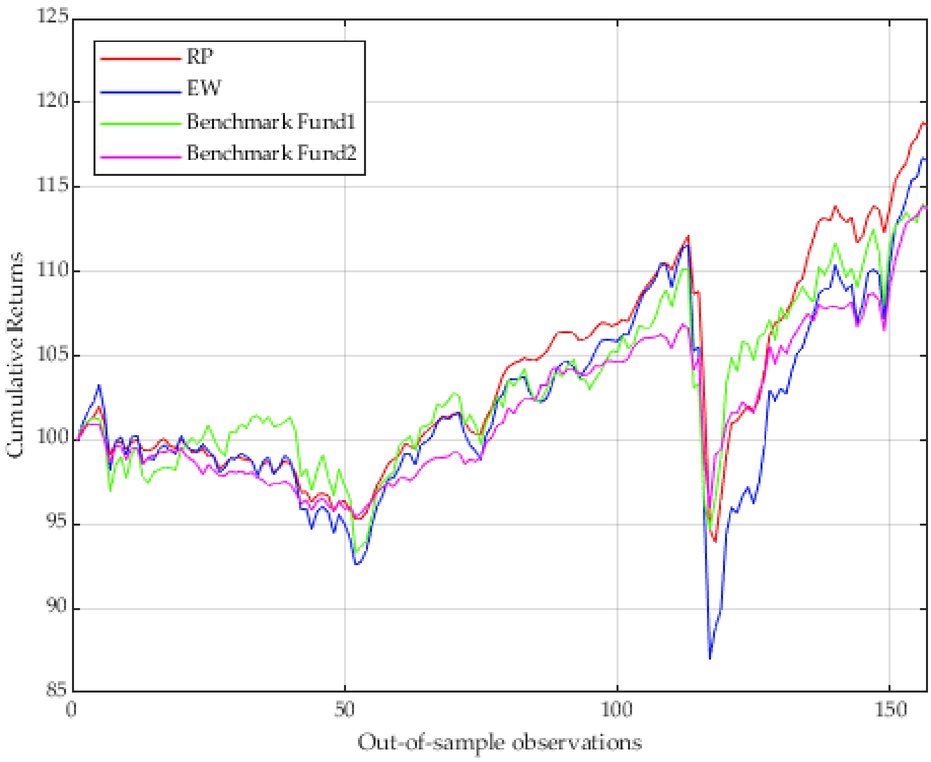
	Mean	Min	Max	Variance
MSCIE	3,71%	2,09%	4,61%	0,002%
MSCIW	3,89%	2,69%	4,58%	0,002%
MSCIEM	3,27%	2,6%	4,75%	0,007%
S&P500	4,02%	2,65%	5,27%	0,003%
CONVBOND	8,14%	6,67%	8,97%	0,003%
REIT	4,45%	2,57%	5,21%	0,001%
High Volatility Assets	27,48%	19,27%	33,39%	0,018%
EUROCORP	15,66%	10,11%	19,47%	0,111%
USCORP	18,32%	16,71%	32,82%	0,029%
EUROIL	17,58%	15,06%	20,28%	0,024%
GOLD	8,27%	5,06%	11,55%	0,027%

Table 6. Assets' marginal risk contributions (MRCs) - Conventional GM Portfolio (out-of-sample period).
Note: This table summarises the assets' MRC to the total portfolio resulting after the optimisation process.

	Mean	Min	Max	Variance
MSCIE	1,39%	1,03%	2,26%	0,0019%
MSCIW	1,34%	0,95%	2,23%	0,0022%
MSCIEM	1,57%	1,26%	2,09%	0,0008%
S&P500	1,32%	0,81%	2,27%	0,0027%
CONVBOND	0,64%	0,46%	1,08%	0,0006%

REIT	1,23%	0,68%	2,28%	0,0037%
High Volatility Assets	7,49%	5,19%	12,21%	0,0118%
EUROCORP	0,4%	0,18%	0,91%	0,0009%
USCORP	0,3%	0,13%	0,55%	0,0002%
FABOND	0,44%	0,21%	0,86%	0,0005%
EUROIL	0,29%	0,19%	0,48%	0,0001%
GOLD	0,62%	0,45%	0,88%	0,0002%

Figure 1. Conventional GM Portfolio Returns (in-sample w = 156; out-of-sample w = 157)
Note: to improve table clarity, returns were normalised on a scale of 100.



6. In this section, we focused on the settlement of the Alternative GM Portfolio. Following the aim of this paper to build and test the performance, hedging and decoupling benefits and risk management, we added to the Conventional GM Portfolio two alternative macro asset classes represented by Sukuk (as Islamic Bonds) and Green Bonds (*DJS, GSSB, GBSOL*). Thus, the Alternative GM Portfolio includes 14 indexes. Again, the observation period consists of 312 weekly returns and the rolling time window relies on 156 weeks in-sample and an out-of-sample of 157 weeks. We applied the Function (1) used to solve the ERC optimisation problem, reporting results and charting the cumulative out-of-sample returns in Table 7 and Figure 2. Unlike the

conventional ones, the Alternative GM Portfolio under the risk parity optimisation recorded an impressive risk-adjusted performance with a Sharpe Ratio equal to 2,55, with an annualised return of 15,24% and a level of volatility of 9,72%. The overall performance of the Alternative GM Portfolio in the ERC approach is the best compared to the Benchmark Funds 1 and 2, except for the maximum drawdown and Calmar Ratio value which is higher than the Benchmark Fund 1. In addition, by increasing the fixed-income component of the asset allocation, the Alternative GM Portfolio recorded better performance than the Conventional. Indeed, looking at Tables 8 and 9, different from previously, the high volatility asset classes' weight contribution and MRCs decrease on average to 19,37% and 7%, respectively. Notably, "alternative" asset classes are well supported by asset diversification since their relevant contribution in terms of risk-adjusted performance. The weight of Sukuk and Green Bonds, respectively, amount to 12,4%, 7,86% and 18,93%, considering their performance during the entire period of observations. During periods of distress, the MRCs of high volatility assets were significant and larger than other asset classes, and generally, the RP model preferred low-volatility assets. For these reasons, in a risk mitigation logic, during high volatility times as during 2020, low volatility asset classes increase the risk-adjusted performance and alternative instruments such as Sukuk or Green Bonds seem to be able to play this role. Finally, looking at the results, Sukuk and green bonds may be integrated into the fixed-income component of the portfolio asset allocation, playing an important role in Global Macro strategies as decorrelating assets.

Table 7. Main Performance of the Alternative GM Portfolio
Note: See notes in Table 4

	EW	RP	Benchmark Fund 1	Benchmark Fund 2
Return (%)	14,51	15,24	12,87	12,78
Volatility (%)	16,12	9,72	10,45	16,33
Max Drawdown (%)	22,96	13,34	11,06	16,27
Sharpe Ratio	1,57	2,55	0,79	1,49
Sortino Ratio	1,04	1,35	1,67	1,19
Calmar Ratio (%)	23,37	38,3	41,22	29,81

Table 8. Asset marginal weight contribution - Alternative GM Portfolio (out-of-sample)
Note: This table summarises the asset weight contribution to the total portfolio resulting after the optimisation process.

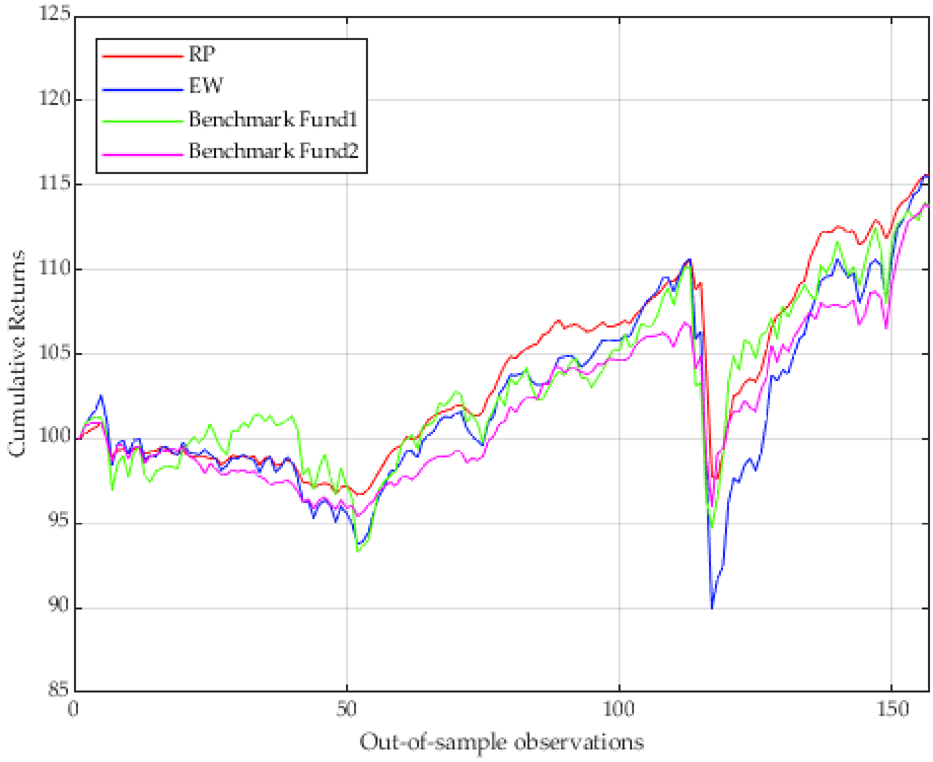
	Mean	Min	Max	Variance
MSCIE	2,44%	1,47%	2,89%	0,0005%
MSCIW	2,52%	1,89%	2,98%	0,0003%
MSCIEM	2,07%	1,59%	3,03%	0,0027%

S&P500	2,61%	1,82%	3,57%	0,0007%
CONVBOND	5,32%	4,48%	6,12%	0,0007%
REIT	2,41%	1,67%	3,1%	0,0006%
High Volatility Assets	19,37%	12,92%	21,69%	0,0055%
EUROCORP	9,85%	6,12%	12,97%	0,0529%
USCORP	10,65%	9,65%	22,54%	0,0127%
FABOND	8,06%	6,69%	10,56%	0,0164%
EUROIL	10,49%	9,32%	11,79%	0,0047%
GOLD	4,4%	3,02%	6,38%	0,01%
DJS	12,4%	10,85%	14,4%	0,0062%
GSSB	7,86%	6,81%	9,91%	0,0041%
GBSOL	18,93%	13,23%	23,45%	0,0521%

Table 9. Assets' marginal risk contributions (MRCs) – Alternative GM Portfolio (out-of-sample)
Note: This table summarises the assets' MRC to the total portfolio resulting after the optimisation process.

	Mean	Min	Max	Variance
MSCIE	1,25%	0,85%	2,1%	0,0021%
MSCIW	1,22%	0,86%	2,1%	0,0023%
MSCIEM	1,45%	1,09%	1,94%	0,0008%
S&P500	1,19%	0,71%	2,14%	0,0027%
CONVBOND	0,58%	0,4%	1,07%	0,0007%
REIT	1,31%	0,73%	2,31%	0,0034%
High Volatility Assets	7,00%	5,64%	11,66%	0,012%
EUROCORP	0,38%	0,17%	0,9%	0,0009%
USCORP	0,29%	0,13%	0,53%	0,0002%
FABOND	0,41%	0,19%	0,83%	0,0005%
EUROIL	0,29%	0,19%	0,49%	0,0001%
GOLD	0,68%	0,54%	0,99%	0,0002%
DJS	0,24%	0,14%	0,41%	0,0001%
GSSB	0,39%	0,23%	0,71%	0,0003%
GBSOL	0,16%	0,09%	0,3%	0,0001%

Figure 5. Alternative GM Portfolio returns (in-sample w = 156; out-of-sample w = 157).
Note: To improve table clarity, returns are normalised on a scale of 100.



7. This paper aimed to contribute to the literature on portfolio systemic risk management, examining the hedge and safe-haven properties of alternative asset classes such as Sukuk and green bonds, for the conventional portfolio strategies, during financial market turmoil as in the Covid-19 crisis. In this paper, we mainly build an Alternative Global Macro Portfolio solving a risk-parity optimisation and using a specifically developed MATLAB™ algorithm. We test the risk-adjusted contribution of Sukuk and green bonds as alternatives to the conventional fixed-income instruments.

As previously mentioned, the Covid-19 crisis has increased the need to manage the rise of systemic risk from portfolio management. In this context, findings show that, in a risk mitigation logic, during high volatility times as during 2020, low volatility asset classes increase the risk-adjusted performance, and alternative instruments such as Sukuk or Green Bonds seem to be able to play this role. Finally, looking at the results, Sukuk and green bonds may be integrated into the fixed-income component of the portfolio asset allocation, playing an essential role in Global Macro strategies as decorrelating assets. Our findings align with earlier empirical studies that reported green bonds as a safe-haven investment and a diversifier for multi-asset portfolios and investment opportunities to curb the economic fragility during stress periods, particularly during COVID-19.

Further research in the portfolio risk management industry and systematic risk mitigation could continue studying, separately and together, the behavior and the performance of this kind of strategy or others adopted mainly by fund managers, also applying more quantitative methods. However, it is necessary to keep in mind that it is impossible to completely delete the effect of the systematic risk in the portfolio risk management, so it is important to find new methods to mitigate and manage it.