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Safe-Haven Currencies as Defensive Assets in Global Stocks Portfolios: A Reassessment of the Empirical Evidence (1999–2022)

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Abstract: This paper reassessed the hedging properties of four major safe-haven currencies (US dollar, Swiss franc, euro, yen) in international stock portfolios covering most representative world macroeconomic areas. The main contribution to the existing literature is the emphasis on optimal hedging and asset-allocation strategies. A further distinguishing feature is an accurate comparison, inside a multivariate framework, between value-at-risk simulations assuming equal or optimal asset weights in hedged global stock portfolios. The US dollar stands out as the best safe-haven currency, while adding the US currency to single-hedged global stock portfolios including either the Swiss franc or the euro yields smooth risk profiles during major financial crises, and average risk indicators lower than that of a benchmark fully hedged portfolio.

Keywords: global stock indexes; safe-haven currencies; optimal asset allocation; hedging effectiveness; value-at-risk; financial crises

JEL Classification: C22; G15

1. Introduction

The last two decades witnessed large turbulences on international financial markets which raised significant challenges for portfolio managers, particularly as regards the design of hedging strategies for global stock portfolios.

Focusing on international equity markets, an extreme volatility in asset returns characterized both the 2007–2009 Global Financial Crisis and the 2010–2012 Eurozone Debt Crisis. These major crises episodes were then followed by other relevant financial turmoil associated with the 2014 Russian Financial Crisis, the 2015 Chinese Stock Market Crash, and the 2018 Turkish Balance of Payments Crisis. Since March 2020, moreover, the COVID-19 pandemic prompted new downward pressures on international equity markets, while the beginning of the Ukraine–Russia war in February 2022 further negatively affected investors' confidence.

A crucial feature characterizing these financial turmoil episodes is the sharp increase in cross-market correlations between global equity returns (Vidal-Tomás and Alfarano 2020; Raddant and Kenett 2021). This empirical regularity reflects an increase in financial contagion on international equity markets (Forbes and Rigobon 2002) and raises crucial implications for the design of optimal asset-allocation strategies. The existence of contagion effects lowers in fact the benefits from international portfolio diversification, since financial crises are characterized by simultaneous falls in stock market returns.

In this context, applied research has devoted increasing attention to explore the properties of safe-haven assets (see e.g., among many others: Ciner et al. 2013; Dimitriou and Kenourgios 2013; Wen and Cheng 2018; Chemkha et al. 2021; Hasan et al. 2021).

This paper focused on an important category of these assets, namely safe-haven currencies, and reassessed their defensive properties in global stocks portfolios during the last two decades.

The main motivation of this research is related to some shortcomings in the existing literature, particularly as regards dynamic optimal asset-allocation problems and the effects of multiple safe-haven currencies inside international stock portfolios.

From this perspective, this paper improves upon the existing literature by providing a more comprehensive assessment about optimal hedging strategies associated with some key safe-haven currencies, and their risk-minimizing effects inside global stock portfolios.

The paper outline is as follows. Section 2 surveys the literature exploring the role of safe-haven currencies in international stocks portfolios. Section 3 describes the dataset and performs a preliminary data inspection. Section 4 contains the results relative to a bivariate framework. This section provides optimal asset-allocation indicators relative to bivariate portfolios, including one stock and one safe-haven currency. Section 5 extends the analysis to a multivariate context. This section estimates standard DCC-multivariate Garch models including all stock returns and one (or more) safe-haven currencies; it then draws on value-at-risk (VaR) indicators associated to the above models in order to investigate the hedging effectiveness of safe-haven currencies. Section 6 concludes, outlining some potential research directions.

2. Safe-Haven Currencies in International Stock Portfolios: A Critical Survey of Applied Literature

Earlier seminal papers identified the US dollar, the Swiss franc, the euro and the Japanese yen as most relevant safe-haven currencies.

Campbell et al. (2010) found that the US dollar, the Swiss franc and the euro are negatively correlated with world equity markets and therefore attractive for risk-minimizing investors, despite their low average returns. In a similar vein, Ranaldo and Söderlind (2010) documented that the Swiss franc, the Japanese yen and, to a lesser extent, the euro display safe-haven properties which materialize non-linearly during crises episodes.

More recent work proceeds along two main research directions:

1.　The former implements various approaches to identify which international key currencies can be considered as safe haven assets.
2.　The latter focuses on the benefits provided by safe-haven currencies and the related optimal hedging strategies.

While the former research line made considerable advances in recent years, many open issues still characterize the latter.

The former strand of literature includes both papers based upon narrative approaches and research relying on various econometric techniques.

Rogoff and Tashiro (2015) apply the "exorbitant privilege" argument to motivate why, although the US dollar still represents the main reserve currency, the Japanese yen enjoyed a safe haven status in the recent period. These authors underline how Japan's status as the world's largest creditor nation and many other financial indicators allow the yen to be considered as a "safe" asset under extreme events.

Lilley et al. (2022) made another contribution based on a narrative approach. Drawing on the emergence of a close relationship between various global risk indicators and a broad US dollar measure, this paper supports the US dollar's role as an international and safe-haven currency since the global financial crisis.

Using a simple regression approach with crises dummies, Kopyl and Lee (2016) showed that the yen stands out as one of the strongest safe-haven investments over a long time-span (1964–2014). Using a factor model to decompose short-term exchange-rate dynamics, Fink et al. (2022) highlighted the role of the Swiss franc as a safe-haven currency. Other quantitative contributions found that the above currencies simultaneously qualify as safe-haven currencies using various Markov–Switching approaches (Lee 2017; Balcilar et al. 2020). Cho and Han (2021) and Tachibana (2022), finally, provide strong empirical support in favor of the yen, the US dollar, and the Swiss franc as safe-haven currencies in international stock portfolios.

I now turn to the latter research line, where many important issues are still unresolved.

Liu et al. (2016) proposed a multivariate extended skew-t copula model to compare the role of the US dollar with that of gold during stock market turbulences. This paper is one of the first attempts to quantify the benefits from safe-haven currencies in global stocks portfolios. In this case, this is done focusing on the lower-tail dependence coefficients of returns series. The main finding is that the US dollar is a better hedge than gold during normal market conditions, whereas both assets can be used as safe havens during stock market crashes.

A major drawback of this paper is that the lower-tail dependence coefficient refers to the bivariate case and, consequently, it only allows for the evaluation of the extreme risk of a pairwise portfolio. Since global market portfolios usually include multiple assets, an extension of this approach to a multivariate framework represents a challenging issue for future research. A further limitation is that, although the underlying econometric model allows the hedging effectiveness of different safe-haven assets to be compared, the computation of optimal asset weights is precluded in this set-up, and therefore the proposed model is not useful from an asset-allocation perspective, at least in its current specification.

Chan et al. (2018) estimated bivariate regime-switching models (high-return/low-volatility state; low-return/high-volatility state) for stock and currency excess returns. Departing from the standard mean-variance framework, the benefits of safe-haven currencies were evaluated in terms of currency co-skewness with the global stock market, namely in terms of covariance between currency returns and global equity volatility. In this skewness preference framework, investors are motivated by "prudence" (Kimball 1990): a higher positive co-skewness means a higher probability that high-equity volatility is accompanied by high-currency returns. The main finding is that, among developed market currencies, the US dollar, the Japanese yen and the Swiss franc exhibit positive co-skewness with the world stock market index. Therefore, in an asset-allocation framework, long positions in these currencies provide a significant hedge against global stock volatility.

The main drawback of this paper is related to the optimal asset allocation problem (a point acknowledged by the authors in their concluding remarks). Departing from the standard mean-variance framework provides a new interesting approach to investigating the hedging value of safe-haven currencies. However, to the best of my knowledge, the design of optimal hedging strategies under these higher moment preferences has not yet been defined in the current literature.

Dong et al. (2021) assessed the hedging properties of the US dollar and gold inside various Asian stock portfolios using a multivariate DCC fractionally integrated asymmetric model and an unconditional quantile regression model. For each country, a trivariate DCC model, including one aggregate national stock index, gold, and the US dollar, was estimated.

From a portfolio-management perspective, this paper extends the seminal Kroner and Ng (1998) contribution, providing optimal weights for a two-asset model, to a multi-asset framework. Empirical estimates from trivariate asset models can therefore be interpreted inside an optimal hedging perspective. One important result is that the US dollar is a better hedge for stock markets under regular market conditions, whereas the safe-haven properties of gold are stronger during major financial crises.

A major innovative feature of this paper is the emphasis on optimal hedging and asset-allocation strategies. A further contribution is the emphasis on a multivariate asset approach. This paper, moreover, provides useful insights to extend the empirical investigation by considering other major aggregate stock indexes and focusing, in addition to the US dollar, on other key safe-haven currencies. Some steps in these directions were taken in the present paper.

3. Dataset and Preliminary Data Inspection

The analysis relies on monthly data from January 1999 to May 2022, yielding a total of 281 observations.[1] This sample extends the time span analyzed in Tronzano (2022), and allows to explore the latest effects of the COVID-19 pandemic and of the beginning of the Ukraine–Russia war. All data are obtained from Thomson Reuters Datastream.

Aggregate stock price indexes are identical to those employed in Tronzano (2022) and are provided by Morgan Stanley Capital Investment (MSCI). These data are expressed in US dollars, since this is the reference currency for international investors, and cover most representative world economic areas (United States, Europe, Japan, Emerging Markets).[2]

In line with the literature survey of Section 2, four major currencies are selected as safe-haven assets, namely: the US dollar, the euro, the Swiss franc and the Japanese yen. All exchange-rate data are provided by JP Morgan and refer to nominal effective exchange rates indexes.[3] Nominal effective exchange rates data provide a more accurate measure (with respect to bilateral exchange rates) of a given currency overall strength on forex markets.[4] An increase in the effective exchange rate level points out, in our case, an appreciation of the safe-haven currency with respect to a representative basket of other major currencies. Positive (negative) changes of effective exchange-rate series indicate, therefore, positive (negative) returns associated with a given safe-haven currency.

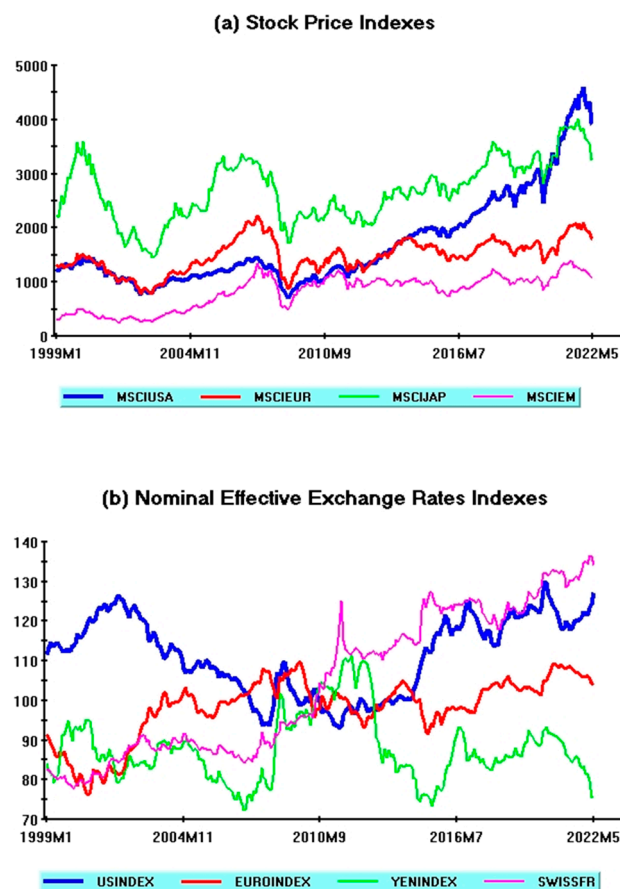Figure 1a,b reproduce, respectively, stock prices and nominal effective exchange-rate levels.

Figure 1. Basic Series in Levels (Monthly Data: January 1999–May 2022).

Focusing on the upper plot (a), the ravaging effects of the 2007–2009 Great Financial Crisis are apparent from the simultaneous sharp downturns of all major stock indexes. Since the beginning of the last decade, moreover, US stock prices exhibit a strong upward trend, while smoother patterns characterize other equity markets.

Turning to nominal effective exchange rates (lower plot (b)), the Swiss currency is the only one to show a long-run appreciation trend, particularly during the latter half of the sample. The US dollar and the euro exhibit almost specular patterns. The US currency is characterized by a strong depreciation trend during the first half of the sample when the euro is particularly strong, whereas these tendencies overturn in more recent years. The Japanese currency, finally, displays a highly erratic pattern, characterized by a temporary appreciation cycle during the central years of the period.

The econometric models implemented in the next sections rely on monthly returns of stock prices and nominal exchange rates, computed taking the log-differences of these variables.[5] Table 1 contains the descriptive statistics for returns series.

Table 1. Descriptive Statistics for Asset Returns. (Monthly Data: February 1999–May 2022; 280 Obs.).

	DUS	DEU	DJP	DEM	DUSD	DEURO	DYEN	DSW
Mean	0.0040	0.0011	0.0014	0.0046	0.0004	0.0004	−0.0003	0.0017
Standard Deviation	0.0 442	0.0526	0.0470	0.0622	0.0132	0.0132	0.0217	0.0129
Skewness	−0.681	−0.679	−0.237	−0.737	0.534	0.366	0.395	0.032
Excess Kurtosis	1.360	1.836	0.425	2.451	2.101	1.143	2.229	9.031
Jarque–Bera	43.2 ***	60.8 ***	4.74 *	95.4 ***	69.0 ***	21.5 ***	65.3 ***	951.6 ***
Arch (1)	27.8 ***	22.8 ***	6.32 **	21.7 ***	9.12 ***	1.41	21.1 ***	15.3 ***
Arch (6)	37.2 ***	31.2 ***	23.9 ***	28.6 ***	10.5 *	10.2	23.3 ***	17.6 ***
Ljung–Box (1)	0.65	2.82 *	4.18 **	8.42 ***	46.1 ***	16.0 ***	22.2 ***	0.74
Ljung–Box (6)	6.57	6.77	13.1 **	12.6 **	49.2 ***	17.0 ***	41.1 ***	4.80
Ljung–Box (12)	10.8	12.2	15.2	15.5	65.6 ***	27.5 ***	56.9 ***	13.5

Jarque–Bera: Jarque and Bera (1980) test for the null hypothesis of normality. ARCH: ARCH test for the null hypothesis of homoscedasticity. Ljung-Box: Ljung–Box portmanteu test for the null hypothesis of absence of serial correlation. DUS: US stocks returns; DEU: European stocks returns; DJP: Japanese stocks returns; DEM: Emerging Markets stocks returns; DUSD: US dollar returns; DEURO: euro returns; DYEN: Japanese yen returns; DSW: Swiss franc returns. ***: significant at a 1% level; **: significant at a 5% level; *: significant at a 10% level.

Average returns are close to zero, in line with the efficient market hypothesis. The variability of stock returns is notably higher than that of currency returns. Among equity returns, moreover, the highest variability is recorded for emerging market stocks.

Stock returns are negatively skewed, pointing out longer tails in the leftward direction, while currency returns exhibit right-skewed distributions.

In line with overwhelming evidence from financial markets, positive excess kurtosis is a pervasive feature of return series, pointing out fatter tails with respect to the normal density. Consistently with the above result, the Jarque–Bera test always rejects the null of normality, in most cases at a 1% significance level.

Strong Arch effects are documented, with one exception (euro returns), suggesting that a multivariate Garch framework is suitable to estimate conditional volatilities.

The Ljung–Box test detects significant first-order serial correlation in most series with few exceptions (US stock and Swiss franc returns). This implies that the use of an AR(1) filter is appropriate in the present empirical investigation. At longer lags (6, 12), some significant serial correlation is apparent from the Ljung–Box test, although almost entirely concentrated on exchange rates returns series.

Table 2 shows the unconditional correlation matrix of asset returns.

Table 2. Correlation Matrix of Asset Returns (Monthly Data: February 1999–May 2022; 280 Obs.).

	DUS	DEU	DJP	DEM	DUSD	DEURO	DYEN	DSW
DUS	1							
DEU	0.858	1						
DJP	0.632	0.641	1					
DEM	0.759	0.815	0.645	1				
DUSD	−0.349	−0.494	−0.366	−0.512	1			
DEURO	0.023	0.140	−0.009	0.084	−0.457	1		
DYEN	−0.260	−0.282	−0.111	−0.276	0.033	0.020	1	
DSW	−0.101	−0.063	−0.098	−0.094	−0.133	0.251	0.249	1

DUS: US stocks returns; DEU: European stocks returns; DJP: Japanese stocks returns; DEM: Emerging Markets stocks returns; DUSD: US dollar returns; DEURO: euro returns; DYEN: Japanese yen returns; DSW: Swiss franc returns.

Correlation coefficients between global stock indexes are always positive and quite high (upper left section of this table), particularly as regards the US-Europe case. Overall, these results reflect the steady capital liberalization process of the last two decades and contagion effects associated with the frequent financial crises episodes. Correlation coefficients between aggregate stocks and exchange rates returns are instead negative or close to zero. The highest negative values are recorded for US dollar correlations with stocks returns.

This suggests that the US currency is a potentially relevant safe-haven currency during the period examined. Negative but lower values are obtained for the Japanese Yen, whereas correlations between the remaining currencies and stock market returns are close to zero.

Correlations between exchange rate returns range between negative and positive values, although in half of the cases they are very close to zero. Swiss franc returns display modest positive co-movements with yen (0.249) and euro (0.251) returns. US dollar and euro returns, conversely, are negatively correlated with greater intensity (−0.457).

4. Empirical Evidence I: Role of Safe-Haven Currencies inside a Bivariate Asset Framework

4.1. Introductory Remarks

The dataset described in Section 3 is now employed to assess the defensive role of four major safe-haven currencies in global stocks portfolios of a representative international investor.

This section focuses on bivariate portfolios including one global stock and one safe-haven currency and computes, for each portfolio, optimal assets weights, optimal hedge ratios, and hedging effectiveness indicators.

Although the applied literature on safe-haven currencies has expanded in recent years, a systematic comparison between the hedging properties of major safe-haven currencies in global stocks portfolios has never been performed. The existing literature, moreover, has not explored the time-varying patterns of optimal hedge ratios during financial crises occurred over the last two decades.

The present section is strictly connected to the empirical investigation performed in Section 5, where a more realistic set up simultaneously including all global stock markets is examined. Value at Risk simulations carried out in Section 5 require detailed information about dynamic optimal asset weights in multivariate global stocks portfolios. As discussed in Section 5, this information relies crucially on optimal portfolio strategies derived in the present section. Therefore, although this section focuses on a less realistic environment (i.e., bivariate asset portfolios), this analysis is propaedeutic to the subsequent empirical investigation.

4.2. Methodology

Modelling time-varying assets conditional correlations, as well as asset conditional volatilities, is a crucial pre-requisite in order to compute optimal dynamic hedging strategies.

To this purpose, the seminal dynamic conditional correlation (DCC) model proposed in Engle (2002) is used. The parsimonious specification of this model avoids the curse of dimensionality problem characterizing other econometric approaches, and this is an advantage in the present context where a large number of DCC models must be estimated.

Engle's (2002) DCC model belongs to the class of multivariate Garch models and is widely used in the applied financial literature related to optimal asset allocation issues.[6]

In order to explore the hedging role of safe-haven currencies in a bivariate framework, four DCC models for asset returns are estimated. Each model includes all aggregate stock returns and one safe-haven currency. The output from these models allows to compute, for each safe-haven currency, the optimal hedging strategy and to evaluate the hedging effectiveness of safe-haven currencies in bivariate stock portfolios.

The specification of DCC models is fully consistent with the preliminary data inspection of Section 3. Since most return series exhibit significant serial correlation, data are preliminarily pre-filtered through an AR(1) process. Visual inspection of residuals from these series confirm that they are well approximated by white noise processes. Since all return series display positive excess kurtosis and the Jarque–Bera test consistently rejects the null of normality, these multivariate Garch DCC models are estimated under the t-DCC specification outlined in Pesaran and Pesaran (2010).[7]

The maximum likelihood algorithm converges after about 50 iterations and all coefficients are statistically significant at standard confidence levels.[8]

The validity of estimated t-DCC models is assessed using the diagnostic tests suggested in Pesaran and Pesaran (2010). The null hypothesis of correct model specification is never rejected at standard significance levels, neither by a Lagrange multiplier test for serial correlation in probability transform estimates nor by a Kolmogorov–Smirnov statistic testing the uniformity of the distribution of probability transform estimates.[9]

The evaluation of hedging benefits provided by safe-haven currencies relies on the standard approach assuming mean-variance preferences, and considers an optimal asset portfolio that minimizes risk without lowering expected returns.[10]

Assume that a representative investor holds a bivariate portfolio with one risky asset (global aggregate stock in our case: "S") and one safe haven asset (safe-haven currency: "C" in our case) to protect his portfolio from excessive return volatility.

Drawing on these assumptions, the optimal weight of the risky asset in a one-dollar portfolio of stock/safe-haven currency at time (t) is given by:

$$w_{SC,t} = \frac{h_{C,t} - h_{SC,t}}{h_{S,t} - 2h_{SC,t} + h_{C,t}} \tag{1}$$

$w_{SC,t} = \begin{cases} 0 & \text{if } w_{SC,t} < 0 \\ w_{SC,t} & \text{if } 0 \leq w_{SC,t} \leq 1 \\ 1 & \text{if } w_{SC,t} > 1 \end{cases}$

where: $h_{C,t}$ = conditional variance of safe-haven currency; $h_{S,t}$ = conditional variance of stock; $h_{SC,t}$ = conditional covariance between stock and safe-haven currency.

The second indicator defines the risk minimizing optimal hedge ratio at time (t):

$$\beta_{SC,t} = \frac{h_{SC,t}}{h_{C,t}} \tag{2}$$

This indicator defines how much a long position (buy) of one dollar in the equity market must be hedged by a short position (sell) in the currency market. Therefore, while a positive ($\beta_{SC,t}$) indicates that a long position (buy) in the risky asset is hedged by a short position (sell) in the safe-haven currency, a negative ($\beta_{SC,t}$) means that optimal hedging implies a long position both in the global stock and in the safe-haven currency.

The last indicator captures the performance of the optimal hedging strategy by comparing the variance of the hedged portfolio to that of the unhedged portfolio.

In the present context, hedging effectiveness is thus defined as:

$$HE_t = \frac{Variance_{Unhedged} - Variance_{Hedged}}{Variance_{Unhedged}} \tag{3}$$

with: $Variance_{Hedged,t} = (w_{SC,t})^2 h_{S,t} + (1 - w_{SC,t})^2 h_{C,t} + 2 w_{SC,t} (1 - w_{SC,t}) h_{SC,t}$

The performance indicator defined in Equation (3) ranges between 0 (no risk reduction) and 1 (perfect hedge). This indicator is therefore useful to compare the hedging properties of the safe-haven currencies in bivariate stock portfolios.

4.3. Empirical Evidence

The risk-minimizing optimal equity weights for bivariate portfolios are reported in Table 3. All data refer to average values computed over the November 2000–May 2022 period.

Optimal equity weights are very low, ranging from minimum values around 0.2 (bivariate portfolios including the euro) to maximum values around 0.3 (bivariate portfolios including the Japanese yen).

Table 3. Optimal Equity Weights in Bivariate Stock/Currency Portfolios. Average Values Computed on Monthly Data: November 2000–May 2022 (259 Obs.).

	Swiss Franc	**Yen**	**US Dollar**	**Euro**
US Stocks	0.247	0.352	0.252	0.231
European Stocks	0.204	0.327	0.249	0.168
Japanese Stocks	0.234	0.300	0.242	0.218
Em. Mark. Stocks	0.189	0.293	0.223	0.170

Optimal equity weights are computed through Equation (1), on the basis of estimated dynamic covariance matrices obtained from DCC models.

These results do not come unexpected, given the much higher variability of stock returns with respect to currency returns.

Optimal risk-minimizing hedge ratios are reported in Table 4.

Table 4. Optimal Hedge Ratios in Bivariate Stock/Currency Portfolios. Average Values Computed on Monthly Data: November 2000–May 2022 (259 Obs.).

	Swiss Franc	**Yen**	**US Dollar**	**Euro**
US Stocks	−0.260	−0.260	−0.479	0.010
European Stocks	−0.182	−0.398	−0.887	0.228
Japanese Stocks	−0.325	−0.030	−0.588	−0.002
Em. Markets Stocks	−0.360	−0.423	−0.969	0.033

Optimal hedge ratios are computed through Equation (2), on the basis of estimated dynamic covariance matrices obtained from DCC models.

All currencies except the euro display negative average hedge ratios; in the US dollar case, moreover, these negative ratios are consistently higher than those recorded for the other currencies.

The optimal hedging policy in bivariate euro portfolios is (almost) always a neutral one: long positions (buy) in global stock markets must not be hedged neither by short nor by long positions in the euro currency market. The only exception is represented by the Euro/European stock portfolio, where a long position in the European stock market must be compensated through short selling in the euro currency market.

Average optimal hedge ratios are instead consistently negative for all other currencies, implying that long positions (buy) in global stock markets must, on average, be hedged through long positions (buy) in these safe-haven currencies (Swiss franc, yen, US dollar).

Since the sample period witnessed many financial crises, possibly characterized by significant portfolio re-adjustments, it is interesting to explore the time-varying patterns of risk-minimizing hedge ratios over time. To the best of my knowledge, this issue has never been addressed in the literature focusing on currency-hedged stocks portfolios. Applied research exploring hedge-ratio dynamics in bivariate portfolios including global stocks and other safe-haven assets has instead documented huge downward shifts in these indicators during financial crises episodes.[11]

In line with these contributions, large downward shifts in optimal hedge ratios during financial crises episodes are expected in the present context.[12]

Figure 2 reproduces time-varying hedge ratios for all bivariate stock/currency portfolios.

This figure contains four distinct graphs referring, respectively, to each safe-haven currency. Vertical bars represent financial crises episodes namely, in chronological order: the Great Financial Crisis (Dum1), the Eurozone Debt Crisis (Dum2), the Russian Crisis (Dum3), the Chinese Stock Market Crisis (Dum4), the Turkish Crisis (Dum5), the COVID-19 Crisis (Dum6). A last green bar at the very end of the sample marks the beginning of the Ukraine–Russia war in February 2022.[13] In all graphs, colored lines refer to time-varying optimal hedge ratios. More specifically: blue lines refer to bivariate portfolios including US stocks; red lines refer to bivariate portfolios including European stocks; green lines refer to bivariate portfolios including Emerging Markets stocks; violet lines refer to bivariate portfolios including Japanese stocks.
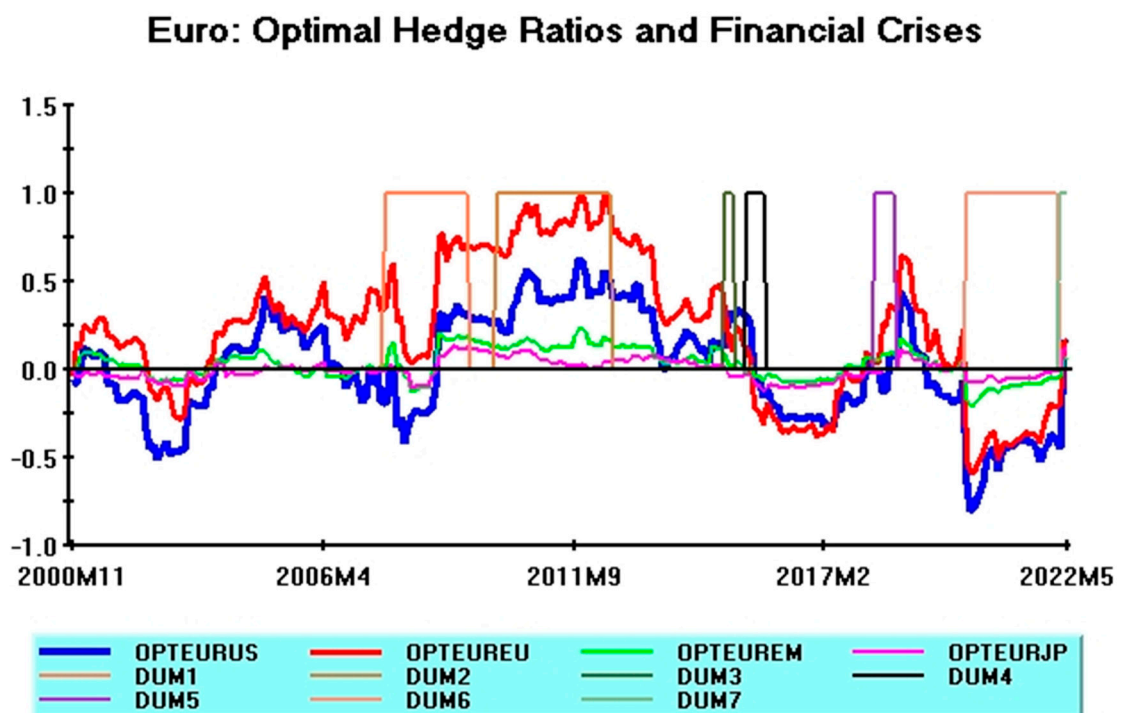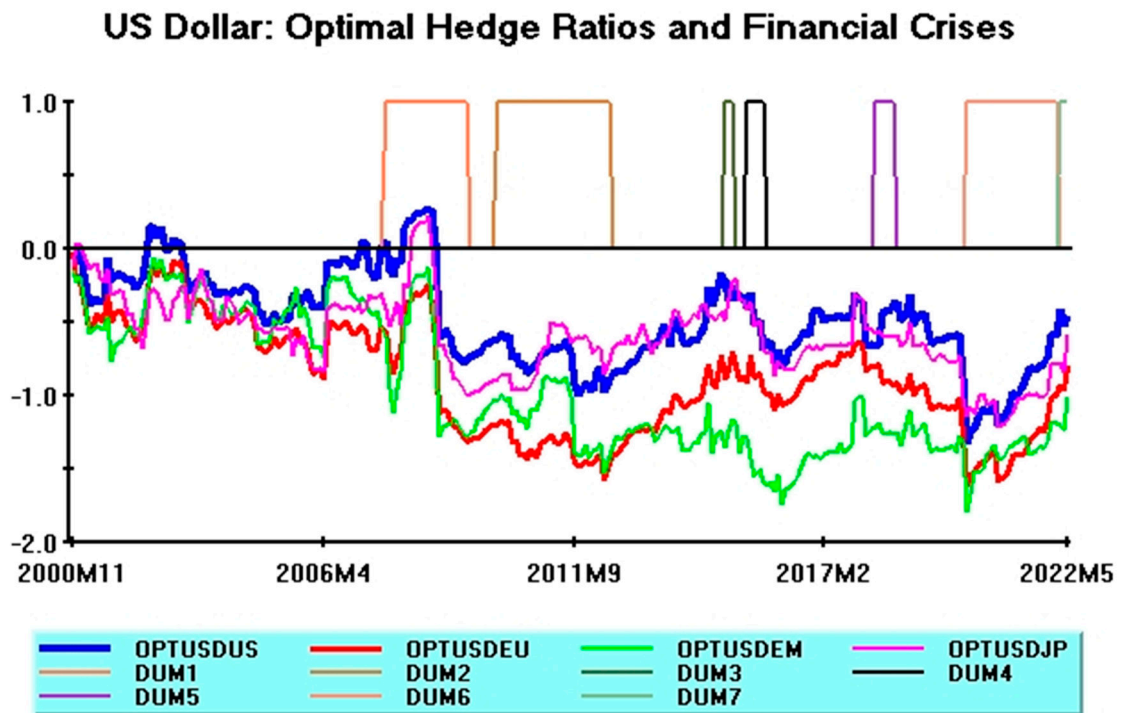
Figure 2. *Cont.*

Swiss Franc: Optimal Hedge Ratios and Financial Crises

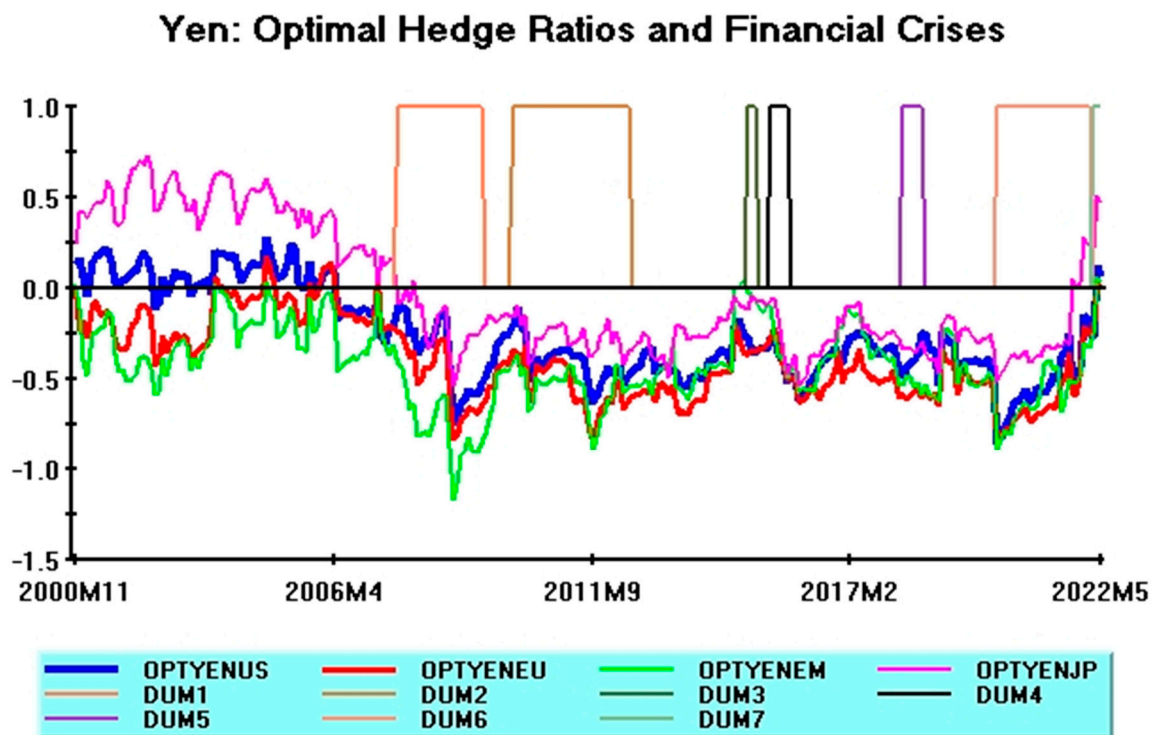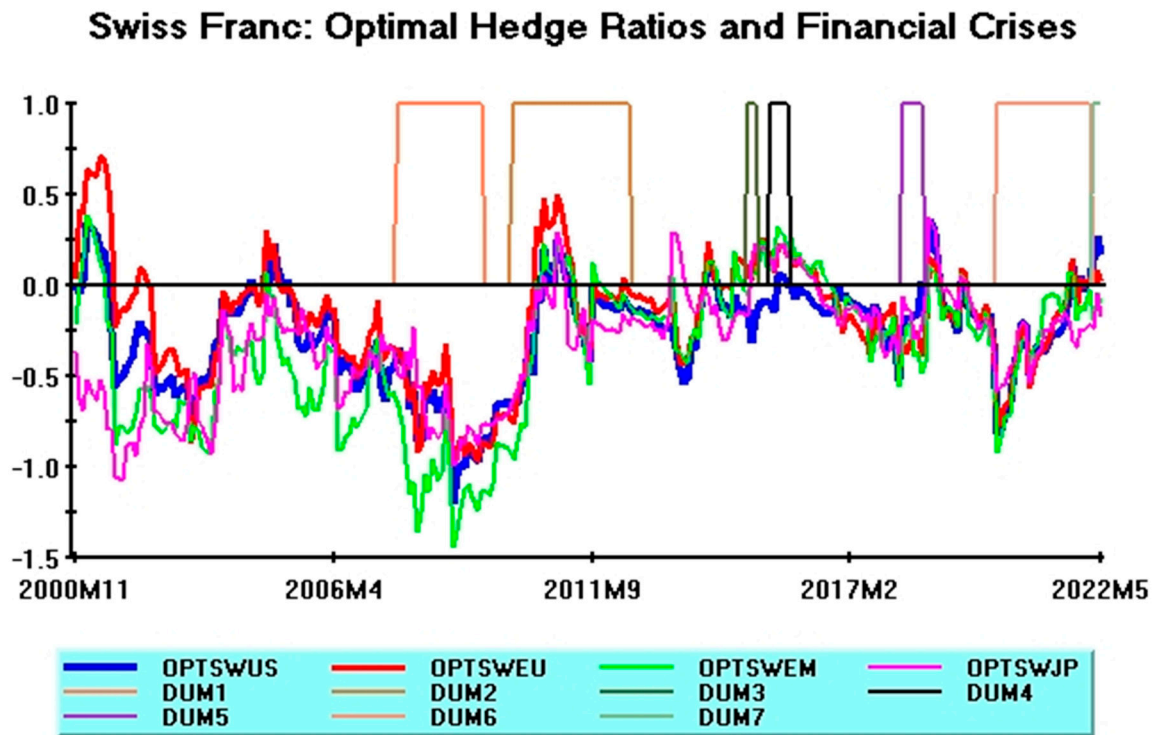## Yen: Optimal Hedge Ratios and Financial Crises

Figure 2. Time-Varying Hedge Ratios (Monthly Data: November 2000–May 2022).

On the whole, the expected path of optimal hedge ratios is largely supported by the empirical evidence.

In most cases, these indicators exhibit large drops during financial turmoil episodes; these drops are pervasive across all safe-haven currencies and turn out to be particularly

strong during the most relevant financial crisis, namely the 2007–2008 Great Financial Crisis. Focusing on this crisis episode (Dum1), Swiss franc and Japanese yen hedge ratios reach absolute negative minimum values, for all bivariate stock portfolios, thus confirming the crucial defensive role of these currencies documented in the earlier literature.[14]

Consider, now, the latter major financial crisis episode, namely the European Debt Crisis (Dum2). The negative values of optimal hedge ratios, together with frequent significant downward jumps in this indicator, are confirmed for the US dollar, the yen and the Swiss franc. Euro-hedged portfolios display instead dynamic hedge ratios seemingly opposite to a priori expectations. Reported ratios oscillate in fact around very high positive values (red line), intermediate positive values (blue line), and positive near zero values (green and violet lines).

These results can easily be interpreted reflecting on the peculiar nature of the Eurozone Debt Crisis.

The 2010–2011 Eurozone Debt Crisis is different from other crises episodes since it does not originate from a real estate bubble (Great Financial Crisis), a domestic stock price bubble (Chinese stock market crisis), macroeconomic imbalances (Russian and Turkish crises), or exogenous extra-economic events (COVID-19 crisis). The European Debt Crisis is a sovereign debt crisis, strictly related to the inability of weakest EU members to refinance their public debts. The peculiar nature of this crisis raised doubts about the survival of the Eurozone and, for this reason, not only major stock markets (mostly European and US stocks), but also the euro currency market were negatively affected. In this perspective, hedge-ratio patterns of euro-hedged stocks portfolios can easily be interpreted.

The high positive values recorded for European stocks (red line) are driven by simultaneous sell-offs on European stocks and European currency markets, prompting simultaneous price falls, and thus a positive covariance between asset returns. The risk of a complete or partial Eurozone implosion negatively also affected US stock returns, although to a lower extent, through contagion effects on international financial markets. This explains the lower, but still positive, hedge ratios recorded for the bivariate US stock/euro portfolio (blue line). Other major macroeconomic areas (Emerging Markets, Japan) were instead basically unaffected by the euro sovereign debt crisis, thus producing almost zero covariances between their stock returns and euro returns (green and violet lines).

Focusing on more recent crisis episodes, neither the Russian Crisis (Dum3) nor the Turkish Crisis (Dum5) exerted appreciable effects on currency-hedged portfolios. Both crises were relatively short-lived and mainly driven by domestic macroeconomic imbalances: this explains the absence of significant effects on optimal hedge ratios.

The 2015 Chinese Stock Market Crash (Dum4), albeit relatively short-lived, produced relevant contagion effects on global stock markets. These effects were witnessed by simultaneous consistent downward trends in optimal hedge ratios of all bivariate portfolios during the second half of 2015.

The last crisis episode is represented by the COVID-19 crisis beginning in March 2020 (Dum6). A huge downward trend in all hedge ratios is apparent at the burst of this crisis. This effect originates from a large common negative shock on stock markets, increasing negative covariances between asset returns in all bivariate portfolios. This evidence further supports the significant hedging role of the four currencies studied in this paper. Subsequent gradual upward movements in hedge ratios capture slow portfolio readjustments towards equities, as the sentiments of global investors gradually improve.

Table 5 contains average values of hedging-effectiveness indicators.

The role of these currencies as powerful hedging instruments is strongly supported by this empirical evidence. For all currencies, the variance reduction generated in stocks portfolios is very high, approximately ranging from 0.7 to 0.9%. The hedging performance of safe-haven currencies is therefore quite similar, although the US dollar is consistently ranked as the best defensive instrument with the Swiss franc strictly behind as a second-best performer.[15]

To sum up, conditional moment estimates from Engle's (2002) DCC model provide interesting results about the risk-minimizing role of major safe-haven currencies during the last two decades. Optimal equity weights are always very low, ranging around 0.2–0.3%,

while for most currencies, negative optimal hedging strategies are supported. The euro stands out as a relevant exception, since for this currency a neutral hedging strategy is optimal, on average, during this period. Although all currencies denote strong defensive powers, the US dollar and the Swiss franc emerge as top performers hedging instruments.

Table 5. Hedging Effectiveness Indicators for Alternative Safe-Haven currencies. Average Values Computed on Monthly Data: November 2000–May 2022 (259 Obs.).

	Swiss Franc	**Yen**	**US Dollar**	**Euro**
US Stocks	0.801	0.728	0.838	0.758
European Stocks	0.823	0.778	0.889	0.779
Japanese Stocks	0.818	0.710	0.862	0.782
Em. Mark. Stocks	0.856	0.804	0.909	0.823

Hedging-effectiveness indicators are computed through Equation (3), on the basis of estimated dynamic covariance matrices obtained from DCC models.

Overall, this empirical evidence is in line with a large proportion of the recent work surveyed in Section 2, which draws on a large set of different econometric approaches (Lee 2017; Chan et al. 2018; Cho and Han 2021; Tachibana 2022; Fink et al. 2022).

5. Empirical Evidence II: Role of Safe-Haven Currencies in Multivariate Stock Portfolios

5.1. Introductory Remarks

As discussed in Section 2, a major drawback of the existing literature is the absence of a consistent analysis of optimal hedging strategies inside a multivariate asset framework. Moreover, in empirical research analyzing the hedging properties of safe-haven currencies, underlying DCC models include a very limited number of financial assets (see, e.g., Dong et al. 2021).

This section contributes to the literature by providing a more comprehensive assessment about the risk-minimizing benefits of safe-haven currencies inside a multivariate asset framework.

This analysis draws heavily on the empirical evidence obtained in Section 4. VaR simulations mimicking a perfectly informed rational global investor rely indeed on optimal dynamic weights computed in a bivariate context.

Estimated DCC models improve upon existing contributions since they rely on a richer baseline specification simultaneously including many global stocks. Additionally, this richer econometric specification relies on a highly flexible structure, since estimated models include one or more safe-haven currencies, while their hedging properties are evaluated under alternative hypotheses about asset weights.

5.2. Methodology

The methodological framework used in this section has the following features:

(a) The econometric approach is identical to that outlined in the previous section, namely is represented by Engle's (2002) DCC model;

(b) A different risk indicator is used to evaluate the hedging performance of safe-haven currencies;

(c) Model simulations comparing the defensive properties of safe-haven currencies rely on the optimal asset-allocation results derived in Section 4.

As regards point (a), estimated models include four stock returns, while currency returns series are dictated by the number of hedging instruments. More specifically: one, two, or three currency returns are included if stocks portfolios are respectively hedged through one, two, or three safe-haven instruments. A more general specification, labelled as "fully-hedged model", includes all currencies in the empirical investigation. In this case, the stocks portfolio is hedged through the largest number of defensive instruments (US dollar, Swiss franc, euro, Japanese yen).

Turning to point (b), hedging strategies are evaluated using a different metric, relying on Value-at-Risk (VaR) indicators. This approach provides a standard measure of portfolio

risk, computing the maximum expected loss at a pre-specified confidence level. For each estimated model, the VaR at the 1% confidence level is simulated, and this standard measure of market risk is used to assess the performance of different multivariate stock portfolios.

As regards point (c), the use of VaR indicators requires a preliminary choice of assets weights. In the present section, VaR indicators are computed, at the 1% confidence level, assuming two different scenarios:

(a)   A "benchmark" scenario (equal assets weights);
(b)   An "optimal" scenario (optimal assets weights).

The former (a) reflects the naïve behavior of a global investor who does not possess any relevant information to guess the expected path of future asset prices and their co-movements. In this situation, each asset is assigned the same weight in global stock portfolios. The latter scenario (b) reflects instead a rational global investor selecting portfolio weights on the basis of informed forecasts about future asset prices, their conditional volatilities, and their conditional covariances.

In order to mimic the (b) scenario, this section makes use of information about optimal asset weights derived in Section 4.

Consider, for instance, the simplest case of four global stocks and one safe-haven currency (US dollar in this example). Using US dollar optimal weights in bivariate stock portfolios, the "average" US dollar "optimal" weight in a multivariate stock portfolio can be computed. Note that US dollar optimal weights in bivariate portfolios exhibit significant co-movements along the whole sample; moreover, since all these variables are time-varying, the "average" US dollar weight is time-varying by construction. For the above reasons, this variable may be considered as an accurate proxy for the US dollar "optimal" weight in a multivariate asset framework. The complement to one of the "average" US dollar weight provides an accurate proxy for the "optimal" weight assigned to the set of global stocks. Since this portfolio includes four stocks, each stock is assigned an "optimal" weight equal to 1/4 of the overall weight for stocks.[16]

The above example refers to the simplest case of multivariate portfolio (i.e., four stocks and one safe-haven currency). However, with suitable modifications in the computations of "average" weights, this procedure can obviously be extended to obtain accurate "optimal" asset weights proxies in larger portfolios including multiple defensive instruments (i.e., two, three, or four safe-haven currencies).

5.3. Empirical Evidence

Table 6 summarizes average values of Value-at-Risk indicators, at the 1% confidence level, simulated from DCC models including four global stocks and alternative hedging instruments.

Table 6. Multivariate Global Stocks Portfolios Hedged through Single or Multiple Safe-Haven Currency. Value at Risk Indicators (α = 0.01). Average Values Computed on Monthly Data: December 2000–May 2022 (258 Obs.).

	USD	SWF	EURO	YEN	USD/SWF	USD/EURO	USD/YEN	YEN/EURO	YEN/SW	EURO/SWF	FULL HEDGE
VaR Equal Weights	0.0788	0.0844	0.0841	0.0840	0.0654	0.0667	0.0640	0.0677	0.0693	0.0698	0.0488
VaR Optimal Weights	0.0234	0.0281	0.0331	0.0433	0.0210	0.0217	0.0262	0.0310	0.0320	0.0281	0.0236

USD: US dollar; SWF: Swiss franc; EURO: euro; YEN: Japanese yen.

In line with the previous discussion, VaR simulations assume two different scenarios: the former with equal asset weights, and the latter with optimal asset weights. Hedging instruments refer to single safe-haven currencies (first four columns), the whole set of currency pairs, and the fully hedged stock portfolio simultaneously, including all currencies (last column).[17]

Consider, first, the average VaR measures associated with the naïve portfolio strategy. As documented in the first row of Table 6, these indicators are notably higher in the case of single-hedging currencies, while they become progressively lower including different

currency pairs, or in the fully hedged portfolio. The VaR associated with the fully hedged portfolio is about 50% lower than that associated with single-currency hedged portfolios. This result strongly supports the risk-minimizing gains stemming from increased portfolio diversification (Markovitz 1952).

Consider, now, average VaR measures associated with the optimal (time-varying) asset weights defined in Section 5.2. Simulations relying on optimal hedging strategies provide, as expected, consistent reductions in VaR indicators. These reductions are particularly strong in single currencies hedged portfolios.

As documented in the second row of Table 6, moreover, these simulations imply that maximum expected losses for currency-hedged portfolios lie in a small interval, ranging approximately from 0.02 to 0.04%.

The US dollar emerges as the best safe-haven currency among VaR simulations assuming optimal asset weights. The US dollar leading position involves both single-currency portfolios (VaR: 0.0234), and two-currencies hedged portfolios where the US currency consistently ranks as the best performer hedging asset together with the Swiss franc (VaR: 0.0210) and the euro (VaR: 0.0217). The Yen, by contrast, is consistently ranked as the worst safe haven asset, both in single and in two-currencies optimal portfolios.

These results reflect the empirical evidence obtained in the previous section, confirming the US dollar leading role as defensive instrument, followed by the Swiss Franc, the euro and, to a greater distance, the Japanese Yen. The fully hedged portfolio, finally, provides satisfactory results, although its VaR is worse than almost all US dollar-hedged optimal portfolios.[18]

Figure 3 plots VaR dynamic patterns of the two best performing asset allocation strategies analyzed in Table 6.

The upper section (a) refers to the fully hedged portfolio; this portfolio displays the lowest VaR under the simple "equal weights" scenario. The lower section (b) refers instead to the US dollar/Swiss franc hedged portfolio, i.e., the one exhibiting, on average, the best risk-minimizing properties under "optimal" asset weights.

Both portfolio strategies are shown in Figure 3: blue lines represent VaR dynamics under the naïve asset allocation strategy, while red lines represent VaR dynamics under "optimal" portfolio weights.

Consider VaR dynamic patterns related to the naïve asset allocation strategy. Comparing blue lines in Figure 3a,b, it is apparent that the risk-minimizing properties of the fully hedged portfolio are consistently better than those of the US dollar/Swiss franc portfolio during the whole sample.[19] These blue lines have an identical pattern, but the VaR dynamics of the fully hedged portfolio (blue line in Figure 3a) is consistently lower than the VaR dynamics of the US dollar/Swiss franc portfolio (blue line in Figure 3b). This is clearly due to the benefits provided by higher asset diversification in the presence of a naïve selection of portfolio weights.

Consider, now, VaR dynamic patterns related to the "optimal" asset allocation strategy (red lines in Figure 3). In line with previous plots, these red lines display almost identical profiles, with minor differences during major financial crises.[20] Differently from previous plots, however, both risk profiles oscillate around a 0.02 value for most of the sample, without any downward-level shift of the line corresponding to the fully hedged portfolio. This means that, in the context of the present example, risk profiles under "optimal" asset weights are basically unaffected by increased safe haven asset diversification.[21]

The empirical evidence summarized in Table 6 and Figure 3 has one important implication for the effective implementation of asset management policies.

During tranquil periods, characterized by low macroeconomic uncertainty and low financial markets volatility, more sophisticated asset allocation strategies, relying on future expected asset returns and their foreseen variance-covariance matrix, are more likely to generate satisfactory risk-minimizing results, closer to the theoretical "optimal" benchmark scenario. A greater emphasis on this approach is thus desirable, under these circumstances, in the context of a global asset allocation strategy.

(a) Fully Hedged Global Stocks Portfolio
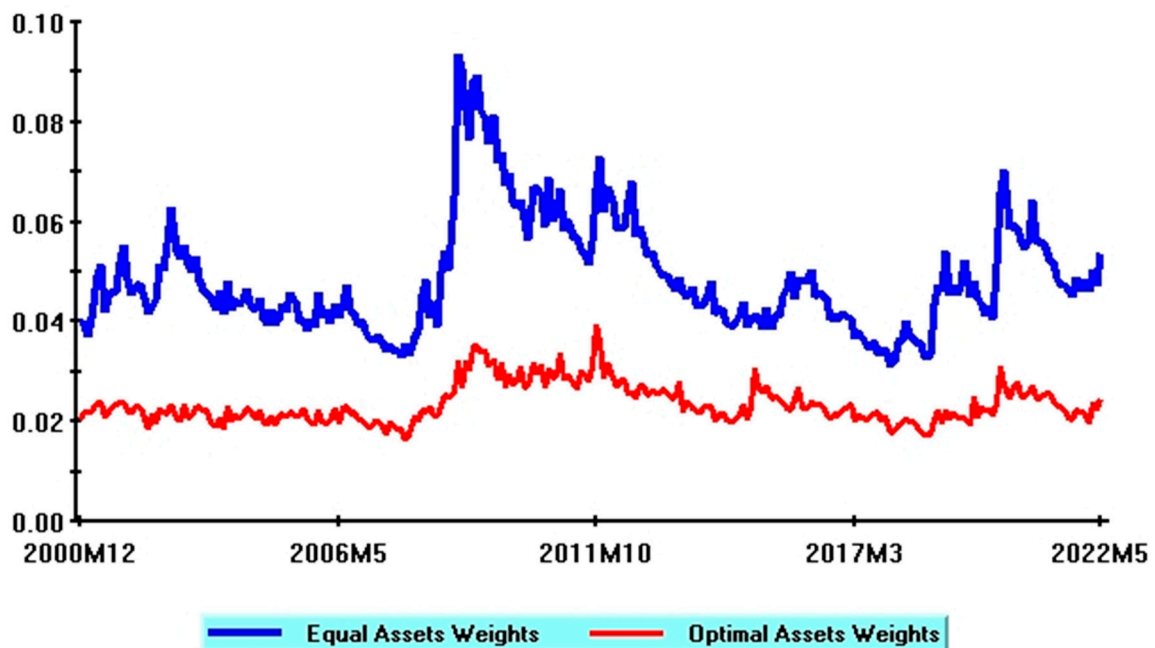
(b) US Dollar / Swiss Franc Hedged Global Stocks Portfolio
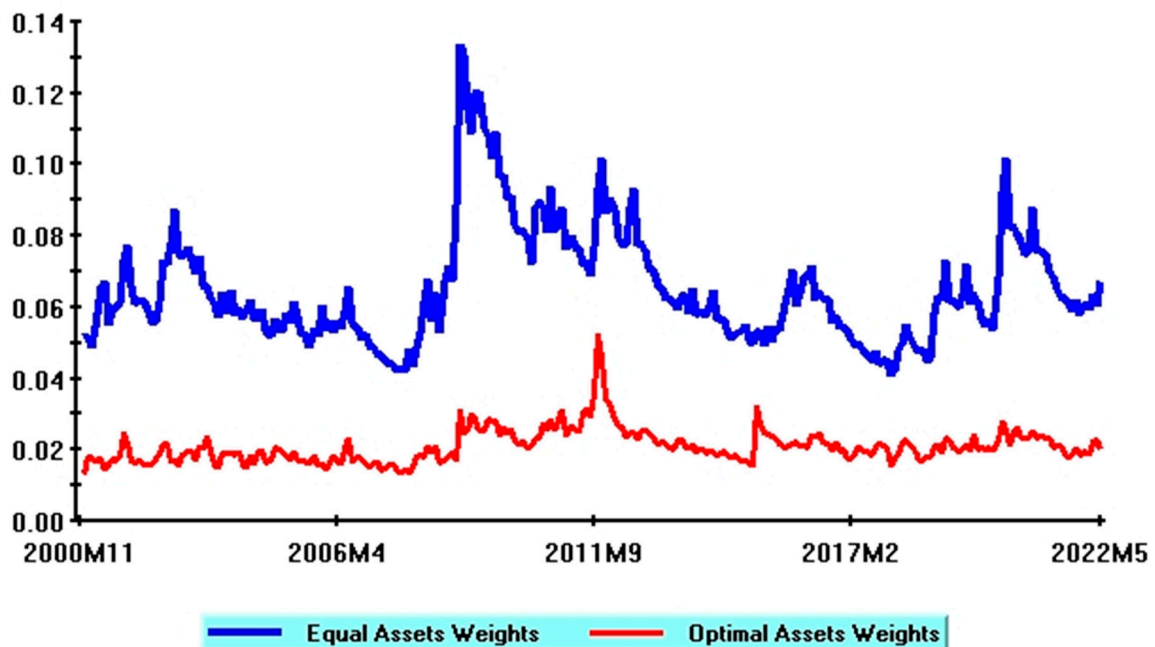

Figure 3. Value-at-Risk in Global Stocks Portfolios: Equal Versus Dynamic Optimal Asset Weights (Monthly Data: November 2000–May 2022).

The converse holds during periods of high macroeconomic uncertainty and financial markets volatility, when a greater emphasis on simpler asset-allocation strategies and a higher degree of portfolio diversification is instead recommended.

This section is concluded analyzing the risk-minimizing properties of all safe-haven currencies, and VaR patterns of differently currency-hedged portfolios during financial crises. Figure 4 reproduces VaR patterns of alternative currency-hedged portfolios.

(a) Single Safe Haven Currencies in Global Stocks Portfolio
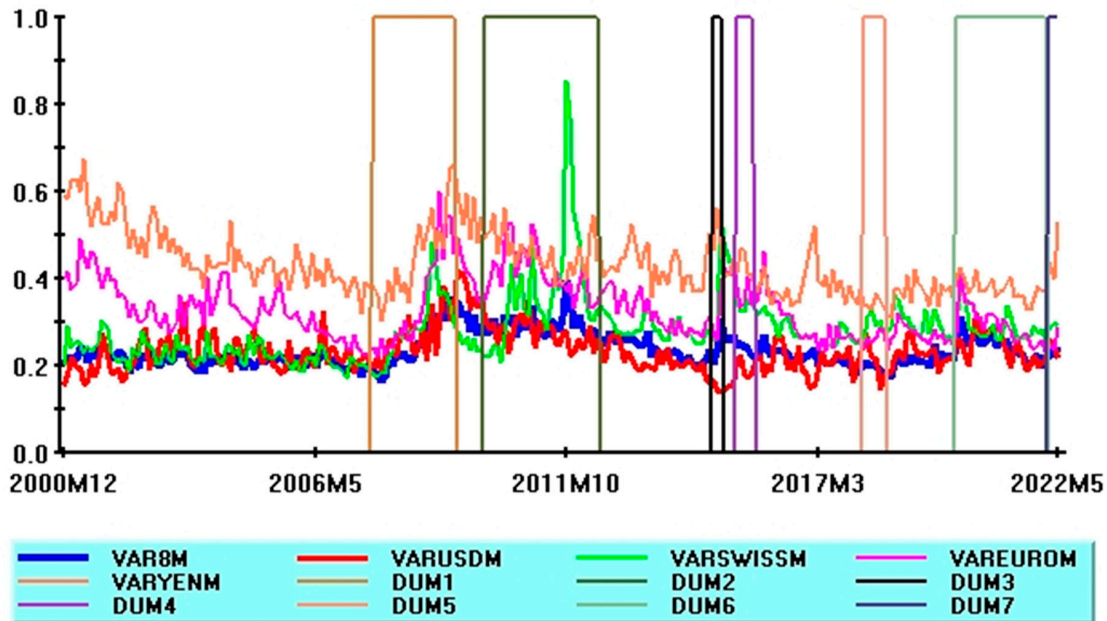
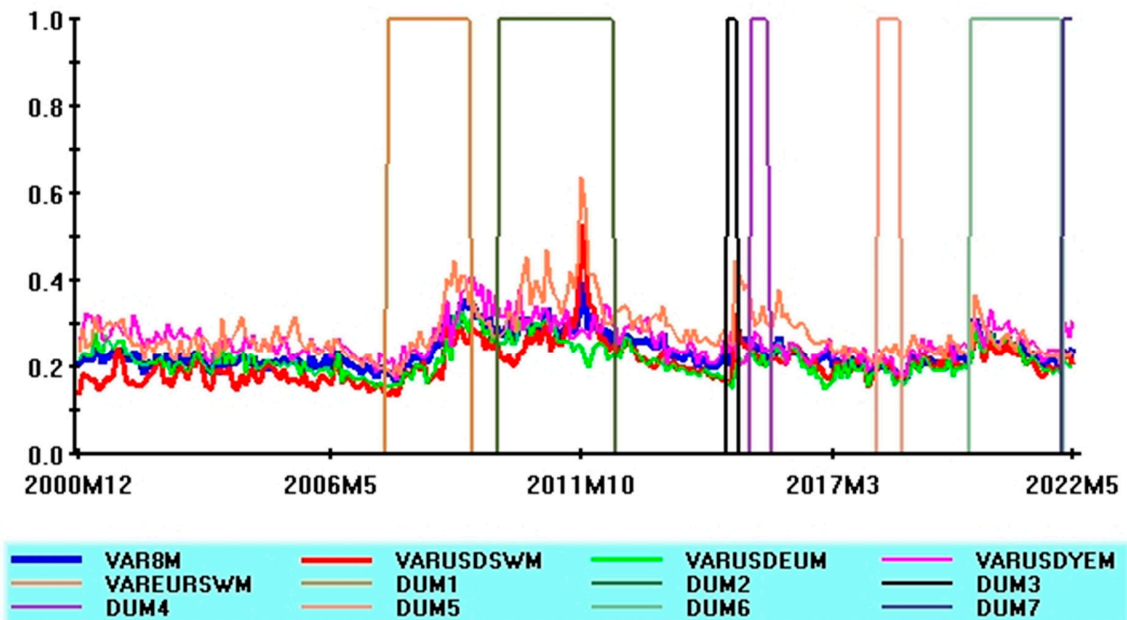## (b) Multiple Safe Haven Currencies in Global Stocks Portfolio

Figure 4. Safe-Haven currencies as Hedging Instruments in Global Stocks Portfolios: VaR Dynamic Patterns (Monthly Data: December 2000–May 2022).

The upper section (a) of this figure refers to single-currency hedged portfolios, while the lower section (b) refers to global stock portfolios including different safe-haven curren-

cies pairs. In the lower section, currency pairs relative to the worst performing portfolios (yen/Swiss franc; yen/euro) are not included in order to make plots more easily readable.

All VaR simulations assume optimal dynamic weights.

Financial crises are indicated by vertical bars marking the beginning and the end of each crisis period[22]; moreover, all VaR appearing in Figure 4 have been rescaled by multiplying them by 10 in order to make plots readable.

Figure 4a,b include, as a benchmark reference, the VaR output associated with the (optimal) fully hedged portfolio containing all safe-haven currencies (VAR8: blue line in both plots). As regards other VaR codes, the acronym in each single-hedged portfolio, indicates the hedging currency in Figure 4a (i.e., for instance, USD indicates the US dollar), while the final capital letter "M" indicates that the series have been rescaled. Analogous codes are used as regards multiple-currency hedged portfolios (Figure 4b).[23]

Before analyzing the empirical evidence from Figure 4 in more detail, it is instructive to take a quick glance at the main features characterizing VaR dynamic patterns of single and multiple-hedged global stock portfolios.

Comparing upper and lower sections of Figure 4, a strong empirical regularity is apparent: plots in the upper section (a) are much more dispersed than plot in the lower section (b). In other words, while single-currency hedged portfolios provide VaR patterns oscillating in a quite large interval (0.20–0.65), multiple-hedged portfolios yield dynamic risk profiles concentrated inside a narrow range (0.20–0.30), excluding some outliers during major financial crisis episodes.

This risk-profile squeezing effect in global stock portfolios provides further visual evidence about the advantages brought about by increased safe-haven asset diversification (Markovitz 1952). These advantages have already been documented comparing, inside a naïve equal weights scenario, VaR dynamics of less and more diversified asset portfolios (Table 6, first row). The visual evidence provided in Figure 4a,b documents that these advantages may be present also inside an "optimal" weights scenario, provided that the more diversified portfolio is compared with a less diversified asset portfolio including only one hedging currency (see also, at this purpose, footnote (21) and the previous discussion about optimal asset weights scenarios in Figure 3).

It is worth stressing that this squeezing effect generated by increased asset diversification is pervasive along the whole sample; actually, as shown by VaR patterns from end-2000 to mid-2007, this effect is independent from the occurrence of financial crisis episodes.

Let us now turn to a more detailed inspection of VaR patterns during financial crisis episodes. Consider, first, single safe-haven currencies in global stock portfolios (Figure 4a).

The US dollar-hedged portfolio (red line) provides the dynamic pattern closest to the benchmark fully hedged portfolio (blue line), thus confirming the leading role of the US currency as a hedging instrument. Although average VaR values for the US dollar are broadly similar to that of the fully hedged portfolio, the latter exhibits a smoother pattern, particularly during the second half of the sample. Differently from other single currency-hedged portfolios, neither the benchmark nor the US dollar-hedged portfolio denote strong VaR increases during the Great Financial Crisis (Dum1). The yen-hedged portfolio, conversely reaches a peak value during this crisis episode.

During the Eurozone debt crisis (Dum2), both the US dollar and the benchmark portfolios display again great VaR stability. The Swiss franc-hedged portfolio denotes instead a huge upward spike in its risk profile, pointing out that a large fraction of its total financial wealth (8%) is potentially at risk at end-2011; moreover, yen- and euro-hedged portfolios display risk profiles persistently oscillating on relatively high values.

After these major financial turmoil episodes, all risk indicators share a common downward trend while, during the subsequent minor crises (Russian Crisis, Chinese Stock Market Crisis) no significant upward tendency in VaR dynamics is observed (except for the Swiss franc-hedged portfolio).

The next short-lived financial crisis, associated with Turkey's balance of payments crisis, does not exert any appreciable risk effects on stocks portfolios. The beginning of

the COVID-19 pandemic in early 2020 witness instead some short-lived, albeit significant, increase in risk profiles of euro and Swiss franc portfolios, whereas both the US dollar and the benchmark portfolios are unaffected. The period corresponding to the beginning of the Ukraine–Russia war is too short to get reliable statistical inferences, although a significant upward jump in the VaR of the Yen-hedged portfolio is observed.

Turning to multiple-currency hedged stocks portfolios, Figure 4b compares the VaR of the same fully hedged portfolio (VAR8: blue line) with the following four alternatively hedged portfolios: US dollar/Swiss franc (red line); US dollar/euro (green line); US dollar/yen (violet line); Euro/Swiss franc (yellow line).

An overall glance at VaR patterns reveals that the US dollar/Swiss franc and the US dollar/euro portfolios are the best performers, since red and green lines in Figure 4b are, on average, the closest to the optimal fully hedged portfolio (blue line). This evidence reiterates the leading role of the US currency.

The US dollar/Swiss franc portfolio denotes modest increases during the Great Financial Crisis. The single Swiss franc portfolio reaps, therefore, great benefits from increased portfolio diversification through the US currency during the worst financial crisis of the last two decades. Analogous significant benefits from higher diversification through the US dollar were documented for other safe-haven currencies (euro and Yen).

The crucial stabilizing role of the US dollar is confirmed during the Eurozone debt crisis (Dum2). The single Swiss franc hedged portfolio, which reached peak values at end-2011 (Figure 4a: green line) exhibits, by means of increased diversification through the US dollar, a drastic reduction in the overall risk profile during this crisis, and a reduction of its peak VaR value from 8 to about 5% (Figure 4b: red line). Analogous consistent risk profiles reductions are recorded in the euro and yen cases.

After the Eurozone debt crisis, a common downward trend in risk indicators is again documented, with the squeezing effect induced by multiple safe-haven currencies diversification reaching higher intensity in Figure 4b.

During the Russian and Chinese Stock Market Crises, the US dollar/euro portfolio (green line) is the one reaping major gains from diversification, significantly outperforming, in both crisis episodes, the benchmark portfolio.

Finally, focusing on the latest turmoil (Turkish and COVID-19 crises), the squeezing effect on risk profiles gains further momentum, although the euro/Swiss franc and US dollar/yen portfolios remain the worst hedge performers.

To sum up, the empirical investigation of this section adds further interesting insights. The better hedging properties of the US dollar are fully confirmed in the present section, where the analysis is extended to a multivariate framework. This evidence is robust across all VaR simulations: namely focusing on single-currency portfolios, multiple currency portfolios, and under different assumptions about asset weights. This analysis, moreover, documents a significant squeezing effect of dynamic risk profiles induced by increased diversification in safe-haven currencies, and a crucial risk-minimizing role of the US dollar in multiple-currency portfolios during major financial crises.

6. Concluding Remarks

Optimal portfolio management has become increasingly difficult to implement during the last two decades, due to the occurrence of a large number of financial crises. These crises originated from a wide set of different factors, ranging from the burst of a real estate bubble (Great Financial Crisis), doubts about public debts sustainability of the weakest European Union members (Eurozone Debt Crisis) or, more recently, extra-economic factors (COVID-19 pandemics). Since this financial turmoil came about almost completely unexpected, it strongly increased downside risks, particularly as regards global stock portfolios. The benefits from portfolio diversification, moreover, lowered during this period, since recurrent crisis episodes sharply increased cross-market linkages, pointing out the existence of contagion effects on international equity markets (Forbes and Rigobon 2002).

Motivated by the above developments, research on safe-haven assets, namely those financial instruments providing hedging benefits during periods of market stress, has attracted increasing attention in recent years.

This paper focused on an important category of these assets, namely safe-haven currencies.

Assuming a standard mean-variance preference framework, this paper focused on optimal asset-allocation strategies of a representative international investor operating on four major macroeconomic areas (United States, Europe, Japan, Emerging Markets), and hedging stock portfolios through four safe-haven currencies (US dollar, Swiss franc, euro, Japanese yen).

The main contribution to the existing literature is a comprehensive assessment of the hedging properties of major safe-haven currencies in global stock portfolios. Moreover, the paper relies on richer and more flexible specifications of DCC models with respect to those usually employed in the current literature, and implements VaR simulations under different assumptions about asset weights.

The empirical evidence may be summarized as follows.

In the first set of results, relying on a bivariate asset framework, all currencies provide satisfactory stabilizing results, although the US dollar stands out as the best performer, followed by the Swiss franc, the euro and the yen. This ranking is consistent across the full set of pairwise portfolios.

In the second set of results, relying on a multivariate asset framework, the ranking of safe-haven currencies is unaffected, thus confirming the leading role of the US currency. As shown by VaR simulations, this result is robust to alternative hypotheses about portfolio weights, namely either assuming naïve "simpleton" portfolios with constant and equal weights, or assuming time-varying "optimal" weights proxied through optimal weights computed in the previous section.

Comparing dynamic patterns of risk indicators, further interesting features emerge.

On the whole, plots of single-currency hedged stock portfolios are higher and more dispersed than those of multiple-hedged stock portfolios, pointing out a favorable squeezing effect on dynamic risk profiles generated by increased (safe-haven) asset diversification. Quite interestingly, this squeezing effect is pervasive along the full sample, and thus independent from the occurrence of financial turmoil.

Focusing on multiple-hedged portfolios, the US dollar/Swiss franc and the US dollar/euro portfolios closely mimic, along the whole sample, the risk profile of the benchmark (fully hedged) portfolio. This favorable squeezing effect induced by higher diversification, is highly persistent along the whole sample, with single-currency portfolios (i.e., Swiss franc-hedged and euro-hedged portfolios) reaping significant benefits from increased diversification through the US dollar.

The main message from this empirical investigation is therefore twofold: (1) The US dollar represents, in absolute terms, the best safe-haven currency over the last two decades; (2) Adding the US dollar to single-hedged global stocks portfolios including either the Swiss franc or the euro is sufficient to obtain highly favorable risk minimizing results, even during major financial crises episodes occurred over this period.

Overall, the concrete implication of these results for portfolio managers is that these key international currencies must be considered as relevant defensive instruments, together with other major safe have assets, in the design of optimal hedging strategies for global stocks portfolios. The number of safe-haven currencies should however be limited to a maximum of two since, according to our empirical evidence, there are no marginal gains in terms of risk reduction beyond this threshold.

Although this paper significantly contributes to the existing literature, two limits of this research suggest some guidelines for future work.

The standard Engle (2002) DCC model was used, in this research, in order to compute the variance–covariance matrix of asset returns. Although the empirical evidence obtained from this model appears quite robust, alternative DCC models, allowing for potential asym-

metries (Cappiello et al. 2006), or leverage and volatility spillover effects (Pan et al. 2022) might be implemented to assess the validity of these results.

From a more general perspective, this empirical investigation drew on the standard mean-variance preference framework. However, as discussed in Section 2, some recent contributions depart from this standard approach, outlining different frameworks to explore the stabilizing properties of safe-haven currencies. Since, under higher moment preferences, the design of optimal hedging strategies is still an open issue, more research efforts in this direction are clearly warranted.

From a wider perspective, finally, it would be interesting to incorporate applied research about the defensive properties of safe-haven currencies into a more general econometric framework, simultaneously assessing the role of other important safe-haven assets. Since this last research line implies the use of large financial datasets, recent contributions on dynamic spatial dependence on international financial markets (Mo et al. 2022), and on Bayesian non-parametric models for large dimensional datasets (Billio et al. 2019) could greatly help in this regard.

Notes

[1] When using monthly data, volatility tends to dissipate with respect to empirical analyses relying on higher frequency observations. The use of the monthly frequency, however, is not unusual in this empirical literature (see, e.g., Filis et al. 2011; Guesmi and Fattoum 2014; Grisse and Nitschka 2015; Chan et al. 2018; Abdul Aziz et al. 2019; Batten et al. 2021; Robiyanto et al. 2021; Tronzano 2022). In empirical analyses relying on monthly data, the sample needs to be sufficiently long in order to get reliable statistical inferences. The use of the monthly frequency is often dictated by the nature of the problem at hand. In Grisse and Nitschka (2015), for instance, this frequency is motivated by the use of augmented UIP regressions. In other empirical contributions, the monthly frequency allows to explore the determinants of hedged portfolio returns through a regression analysis using macroeconomic variables, which are available only at this frequency (Batten et al. 2021).

[2] As regards stock price indexes, the relevant references and Thomson Reuters codes are the following: United States: MSCI United States of America, Thomson Reuters code: "MSUSAML"; Europe: MSCI Europe Index, Thomson Reuters code: "MSEROP$"; Japan: MSCI Japan Index, Thomson Reuters code: "MSJPAN$"; Emerging Markets: MSCI Emerging Markets U$, Thomson Reuters code: "MSEMKF$".

[3] As regards nominal effective exchange rate series, the relevant references and Thomson Reuters codes are the following: US dollar Nominal Effective Exchange Rate, Thomson Reuters code: "USJPNEBBF"; Euro Nominal Effective Exchange Rate, Thomson Reuters code: "EAJPNEBBF"; Swiss franc Nominal Effective Exchange Rate, Thomson Reuters code: "SWJPNEBBF"; Japanese yen Nominal Effective Exchange Rate, Thomson Reuters code: "JPJPNEBBF".

[4] Exchange rates data used to analyze optimal hedging strategies depend on the specific perspective of international investors. If the analysis is carried out from the perspective of a US investor, bilateral exchange rates against the US dollar are clearly recommended (see, e.g., Kopyl and Lee 2016, sct. 3.2). However, if the analysis is carried out from the perspective of a global international investor, as in the present paper, the use of effective nominal exchange rates is more appropriate. Global worldwide investors are in fact interested in hedging strategies preserving portfolio wealth against a basket of international currencies, rather than against a single currency. Tachibana (2022) provides a recent example of research exploring the safe haven properties of various assets in international stocks portfolios using nominal effective exchange rates relative to a large number of developed economies. In a similar vein, Fink et al. (2022) use both bilateral and effective exchange rates of some major currencies (Euro, US dollar) to model different global factors driving Swiss franc dynamics during the last decades.

[5] Standard unit root tests reveal that all series in log-levels are non-stationary, whereas all log-returns series are stationary. Unit root tests are not reported here in order to save space, and are available upon request. For the same reason, plots of asset return series are not included and are available upon request.

[6] A formal description of the basic structure of this model is not provided here in order to save space but can be easily be found in the huge financial literature relying on this econometric approach. Engle (2002) provides the original description of the DCC model. This model has been widely used, in subsequent years, to explore the nature of stock returns correlations (see, among many others, Pesaran and Pesaran (2010)) and contagion effects on stock markets (see, among many others, Hemche et al. 2016). A huge strand of research has also used this model to explore dynamic linkages among different financial assets categories (see e.g., Ciner et al. 2013; Ansul and Biswal 2016). More recently, an equally large strand of literature relied on Engle (2002)

econometric framework to assess the properties of various safe haven assets categories or to explore the role safe haven assets during the COVID-19 outbreak.

7   Under this alternative distributional assumption, Engle (2002) original two-step estimation procedure is no longer applicable. The Maximum Likelihood estimator relies now on a more efficient approach, involving the simultaneous estimation of model's parameters and an additional degrees-of-freedom parameter relative to the multivariate t distribution (see Pesaran and Pesaran (2010, sct. 4) for technical details).

8   Maximum Likelihood estimates from these models are not reported in order to save space and are available upon request. Few parameters restrictions are imposed to obtain convergence. More information about these restrictions are available upon request.

9   See Pesaran and Pesaran (2010, sct. 5), for a technical discussion on conditional evaluation procedures based on probability integral transforms. Under the null hypothesis of correct model specification, probability transforms estimates are serially uncorrelated and uniformly distributed in the interval (0, 1).

10 The theoretical and econometric underpinnings for dynamic hedging models assuming time-varying conditional moments are laid down in Kroner and Sultan (1993) and Kroner and Ng (1998) seminal papers. The subsequent literature has intensively used this approach, drawing on various econometric techniques to estimate dynamic covariance matrices. See for instance, among many others: El Hedi Arouri et al. (2015); Mensi et al. (2017a, 2017b); Hussain Shazad et al. (2020).

11 El Hedi Arouri et al. (2015) investigate gold hedging and diversification strategies related to the aggregate Chinese stock index, and document significant downward shifts in optimal hedge ratios during the 2007–2008 Great Financial Crisis. Similar large drops in optimal hedge ratios are documented in Basher and Sadorsky (2016) during the 2010–2011 Eurozone Debt Crisis, focusing on an aggregate Emerging Markets stock index and the defensive properties of oil, gold, the US 10-year Treasury Note and the VIX.

12 The intuition is as follows. Consider a bivariate stock-currency portfolio. During a financial crisis, major stocks sell-outs generate sharp downward falls in stock returns; on the other hand, if the selected currencies are robust safe haven assets, their returns are unaffected or can even increase in case of portfolio re-adjustments from stocks to safe-haven instruments. Overall, these effects tend to increase the negative correlations values between stocks and currency returns documented in Table 2 for most currencies. The associated fall in conditional covariances, moreover, is amplified by significant increases in stock volatilities, a typical empirical regularity occurring during financial turmoil. To sum up, sharp downward falls in risk-minimizing optimal ratios ($\beta_{SC,t}$) defined in Equation (2) are likely to materialize during most financial crisis episodes, driven by sharp plunges in conditional covariances between asset returns and relatively low volatility levels characterizing safe-haven currencies (see Table 1).

13 The reader is referred to Tronzano (2021, sct. 3), and to Tronzano (2022, sct. 4), for a description of the basic features of these crises and their chronology.

14 See, e.g., among many others, Lee (2017). This paper relies on a Markov–Switching approach in an empirical investigation about six major currencies and concludes that the Swiss franc and the Japanese yen qualify as strong safe havens.

15 Dynamic patterns of hedging effectiveness indicators are not shown here in order to save space, but are available upon request. Overall, US dollar values display a remarkable stability, whereas a slightly higher instability is observed for other currencies.

16 This procedure yields accurate proxies for single "optimal" stocks weights since, as documented in Table 3, average optimal equity weights represent a small fraction of all bivariate portfolios (ranging between 0.20–0.30); their time patterns, moreover, are characterized by significant co-movements and limited variability.

17 In a preliminary empirical investigation, a VaR simulation including the three more powerful hedging currencies (US dollar, Swiss franc, euro) was also performed. Since these results do not add any relevant information with respect to that displayed in Table 6, they are omitted in order to save space.

18 The evidence obtained assuming "optimal" asset weights must be interpreted with great care. This evidence, as well as hedging effectiveness indicators derived in Section 4, is computed through "ex-post" empirical exercises. VaR simulations, in other words, are built on perfect foresight forecasts about future asset returns and their variance-covariance matrix. These simulations are a purely theoretical exercise, as such unfeasible in the real world. Portfolio managers face indeed an incomplete information set, information asymmetries, and unpredictable random shocks during their (ex-ante) forecasting process necessary to implement asset allocation choices. Value-at-risk indicators represent therefore a theoretical "optimal" benchmark scenario mimicking the risk-minimizing properties of alternatively hedged asset portfolios.

19 For instance, during the Great Financial Crisis, the "Equal Asset Weights" strategy records a peak value of only 0.09 in the former portfolio (Figure 3a), whereas the same strategy records a much higher value around 0.13 in the latter (Figure 3b). Analogous differences can be observed during the Eurozone Debt Crisis.

20 During the period corresponding to major financial crises (Great Financial Crisis, Eurozone Debt Crisis), i.e., from 2008 to mid-2012, the VaR of the fully hedged portfolio exhibits an initial jump and then a smooth pattern, whereas that associated with the US dollar/Swiss franc hedged portfolio denotes a more erratic pattern.

21 Note however that the favorable effects of increased safe-haven currency diversification can operate, even under "optimal" asset weights, if global stock portfolios contain only one safe-haven currency. I will return on this issue later on, when commenting the empirical evidence summarized in Figure 4.

[22] More specifically, these financial turmoil period include: Great Financial Crisis: Dum1 (orange bars); Eurozone Debt Crisis: Dum2 (dark green bars); Russian Crisis: Dum3 (black bars); Chinese Stock Market Crisis: Dum4 (violet bars); Turkish Financial Crisis: Dum5 (orange bars); COVID-19 Financial Crisis: Dum6 (light green bars); beginning of Ukraine/Russia War Crisis: Dum7 (blue bar). See Tronzano (2022, sct. 3), for the exact chronology of these crisis periods.

[23] The complete list of VaR codes, for each hedged stock portfolio, is the following: Figure 4a: VAR8M: fully hedged portfolio (blue line); VARUSDM: US dollar hedged portfolio (red line); VARSWISSM: Swiss franc hedged portfolio (green line); VAREUROM: euro hedged portfolio (violet line); VARYENM: yen hedged portfolio (yellow line); Figure 4b: VAR8M: fully hedged portfolio (blue line); VARUSDSWM: US dollar/Swiss franc hedged portfolio (red line); VARUSDEUM: US dollar/euro hedged portfolio (green line); VARUSDYEM: US dollar/yen hedged portfolio (violet line); VAREURSWM: Euro/Swiss franc hedged portfolio (yellow line).

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