COVID-19 and the safe haven role of US dollar: A threshold regression analysis

Felice d'Esposito

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Abstract

The ongoing COVID-19 pandemic has shaken the global financial system and caused great turmoil. Facing unprecedented risks in the markets, people have increasing needs to find a safe haven for their investments. Given that the nature of this crisis is a combination of multiple problems, it is substantially different from all other financial crises known to us. It is therefore urgent to re-evaluate the role of traditional safe haven candidates. The aim of this thesis is to test the hypothesis that the United States Dollar represents a safe haven against stocks of all developed countries during COVID-19 pandemic. I implement a threshold regression model to capture the non-linear linkages between safe haven assets and global stock markets, which is largely documented in the recent literature. Indeed, my empirical approach allows me to distinguish between a low- and high-stress regime, and to control for the impact of carry trade reversals. According to the estimation results, the US dollar acted as a strong safe haven during COVID-19 pandemic, experiencing no significant influence of carry trade dynamics. My results, paired with those of previous research on the haven-linked US dollar, further suggest that the safe haven role of a given asset may be sensitive to changes over time and across markets.

A situação pandémica provocada pela COVID-19 abalou o sistema financeiro global, causando grandes perturbações no mesmo. Deparando-se com riscos sem precedentes nos mercados, as pessoas procuraram incansavelmente um “safe haven” para os seus investimentos. Tendo em conta que a natureza desta crise é um compilado de múltiplos problemas, esta torna-se substancialmente diferente de todas as crises financeiras pelas quais já passamos. É por isso urgente reavaliar o papel dos tradicionais candidatos a “safe havens”. O propósito desta tese é assim testar a hipótese de que, no meio desta pandemia, o dólar dos Estados Unidos representa essa seguridade contra as ações de todos os países desenvolvidos. Para fazer esse estudo, implementei um modelo de regressão limiar de modo a capturar ligações não lineares entre ativos seguros e o mercado global de ações, amplamente documentado na literatura recente. Deste modo, a minha abordagem empírica permitiu-me distinguir entre baixas e altas condições de tensão e controlar o impacto das inversões “carry-trade”. De acordo com os resultados estimados, o dólar americano agiu como um “safe haven” durante a pandemia COVID-19, não experienciando influências significativas nas dinâmicas “carry-trade”. Os meus resultados, em conjunto com pesquisas feitas sobre a ligação do “haven” com o dólar americano, sugerem que o “safe-haven” de um determinado ativo pode ser suscetível a mudanças ao longo do tempo e entre mercado.

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1. Introduction

Since the initial outbreak of COVID-19 in February 2020[1], global financial markets have faced enormous risks. The US equity benchmark S&P500, for example, hit a stunning one-day-drop of -11.98% on 16th March 2020[2]. The COVID-19 pandemic, which has been considered a "once-in-a-century" (Gates, 2020), impacted stock markets more than any previous infectious disease outbreak, including the 1918 Spanish Flu (Baker et al., 2020). More astonishing, on 20th April 2020, crude oil futures for the West Texas Intermediate (WTI), the US oil benchmark, closed at an unprecedented level of -$37.63 per barrel. Such unforeseen and unanticipated events trigger "flight to quality" episodes where investors reallocate their investments from risky to safe-haven assets (Caballero and Krishnamurthy, 2008). Indeed, facing great losses after the outbreak of the ongoing pandemic, the need to search for safe-haven assets has resurfaced for both practitioners and researchers.

A safe haven is defined as a place of safety or refuge. In times of stormy weather, ships seek out the safe haven of a port or harbor to ride out the storm. A safe haven asset must therefore be some asset that keeps (or even increases) its value in 'stormy weather' or adverse market conditions. Such an asset offers investors the opportunity to mitigate the downside market risk. It is well documented in the literature that currencies such as the US dollar and Swiss Franc (e.g. Grisse and Nitschka, 2015; Kaul and Sapp, 2006; Ranaldo and Söderlind, 2010; Hossfeld and McDonald, 2015) act as safe havens during periods of stock market turmoil. However, the question is whether their ability to protect investments remains true in the current crisis. To emphasize the importance of finding an answer to this question, previous research shows that the safe haven property of an asset is subject to significant changes over time, according to the nature of the crisis triggering a surge in global risk-aversion (De Bock and de Carvalho Filho, 2015; Ji, Zhang and Zhao, 2020; Cheema, Faff and Szulzyk, 2020). Thus, the COVID-19 pandemic provides an enticing research setting to examine whether the traditional safe haven currencies provide protection from stock market losses given the unique nature of this twin health/economic crisis.

In particular, this paper aims to investigate whether the United States Dollar (USD or greenback hereafter) deserves the safe haven status during the COVID-19 pandemic. The motivations for this objective are mainly the following. On the one hand, as far as the USD

[1] Although the disease had already started spreading in China at towards the end of 2019, it has turned into a global health crisis only through late-February and early-March 2020.
[2] Source: Investing.com website.

movements for the whole 2020 and through 2021 are concerned, one could observe that these movements are consistently influenced by the variations in investors' appetite for the greenback. Further, a major perception is that the USD has been moving in opposite direction with respect to global equities throughout the entire period characterized by the health crisis. On the other hand, global markets analysts and financial media regularly refer to the USD as a "safe haven asset". As an illustration, a CNBC article published on 19th August 2020 reports how Morgan Stanley analysts had just picked the USD as "the best safe-haven currency" in what was left of turbulent 2020[3].

I provide an empirical framework to test whether the hypothesis of the USD serving as a safe haven asset during the COVID-19 pandemic is supported by statistical evidence. I adopt the definition of a safe haven currency from Hossfeld and McDonald (2015). In other words, a currency is defined to be a safe haven if its effective returns are significantly negatively related to global stock market returns in times of high financial stress, even when controlling for the impact of carry trades (or respectively, their reversal) in which the currency has served as carry funding currency[4]. To this end, I first run an Ordinary Least Squares (OLS) regression of DXY Dollar Index returns on global stock market returns, the latter interacted with a dummy which identifies highly stressed financial conditions based on the value of the VIX index. Next, I test the robustness of the results by estimating Hansen (2000) threshold regressions for USD effective returns, where the VIX financial stress-threshold values separating the low- from the high-stress regime are determined endogenously.

In the light of that, I find the USD to be consistently and robustly significant in serving as a safe haven during COVID-19 pandemic. This result contradicts the findings from Ji, Zhang and Zhao (2020) and Cheema, Faff and Szulzyk (2020). Indeed, within their re-evaluation of the role of traditional safe-haven assets during this pandemic period, they find no evidence of a safe haven behavior for the USD. My suspect is that this contradiction is due to the combination of three main differences between my study and their studies.

More specifically, the contributions of this paper are as follows. First, in order to properly examine the role of the greenback during the ongoing pandemic, I expand the sample period analyzed by Cheema, Faff and Szulzyk (2020) which ends on 19th May 2020 (the sample span of Ji, Zhang and Zhao (2020) is even narrower), by collecting data up until the end of February 2021. This choice is by no means random, but it rather relies on the evidence

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[3] Link for the article: "Morgan Stanley just picked this year's best safe-haven currency".

[4] For further details on the relationship between the profitability of carry trade strategies and global risk aversion, check Brunnermeier et al., 2008; Lustig et al., 2011; Menkhoff et al., 2012.

that markets have finally been able to leave behind the pandemic-driven turmoil only once the vaccines roll-out programs have picked up speed in Q1 of 2021. As an illustration of that, the VIX "fear" index has closed back below the psychological level of 20 only on 12th February 2021, after marking consistently higher levels since the initial outbreak of COVID-19.

Secondly, I make use of the MSCI Developed Markets Index as a proxy for global equities[5], while Cheema, Faff and Szulzyk (2020), as well as Ji, Zhang and Zhao (2020), analyze stock returns from single countries, with about half of which being characterized by developing economies such as China, India and Brazil. However, Baur and McDermott (2010) find strong evidence that investors in emerging markets react differently to downside shocks. They do sell their shares in response to a negative market shock, but rather than seeking the shelter of a safe haven asset, they are instead more willing to shift their portfolios towards the relative safety of developed world markets. This is the reason why I prefer using a broad index comprehensive of all and only the advanced world markets for the purpose of this research.

Finally, in contrast to Ji, Zhang and Zhao (2020), I analyze effective as opposed to bilateral exchange rates. This allows me to gauge the impact of the USD safe haven status on the international rather than local stage. As noted by Cheung et al. (2007), "Trade weighted rates are to be preferred to bilateral rates since the reliance on the latter can lead to misleading inferences about overall competitiveness". In other words, if bilateral currency pairs are analyzed separately, one would only be able to infer whether a particular currency acts as a safe haven relative to one other currency, and not in an absolute sense, which is what we should really think of when speaking about a "safe haven currency". Furthermore, by analyzing the effective exchange rate, I avoid the issue that the USD and another "similar" safe haven currency "cancel each other out" if one of them is denoted in the numerator and the other in the denominator of a bilateral exchange rate (Hossfeld and McDonald, 2015). With this intention, I make use of the U.S. Dollar Index (DXY or, informally, the "Dixie"), which is a measure of the value of the USD relative to a basket of foreign currencies, often referred to as a basket of U.S. trade partners' currencies[6]. The Index goes up when the USD

[5] The MSCI World is a market cap weighted stock market index of 1,585 companies throughout the world. It is maintained by MSCI, formerly Morgan Stanley Capital International, and is used as a common benchmark for 'world' or 'global' stock funds intended to represent a broad cross-section of global markets. The index includes a collection of stocks of all the developed markets in the world, as defined by MSCI. The index includes securities from 23 countries but excludes stocks from emerging and frontier economies.

[6] The index is designed, maintained, and published by ICE (Intercontinental Exchange, Inc.). It is a weighted geometric mean of the dollar's value relative to the following currencies: Euro (EUR), Japanese yen (JPY), Pound sterling (GBP), Canadian dollar (CAD), Swedish krona (SEK) and Swiss franc (CHF). Check Table A2 in the Appendix for further information about trade weights for all the currencies included in the index.

gains "strength" (or value) when compared to the other currencies and drops in the opposite case.

The remainder of the paper is organized as follows. Section 2 presents a selective review of the related literature on studying safe-haven assets. Section 3 discusses and motivates the main econometric methods applied. Section 4 describes the data used in the analysis and presents empirical results. The conclusion to my findings is given in Section 5.

2. Literature review

The “safe haven” label has been easily attached to several different assets throughout a number of publications and academic articles aiming to find evidence of those assets appreciation when investors care mainly about protecting their capital. But, as highlighted by Hossfeld and McDonald (2015), considerably fewer research stepped back for a second and focused on what precisely a safe haven asset is at the end of the story. A first attempt in that direction is Baur and Lucey (2010) in their analysis of whether gold constitutes a safe haven asset. They define a safe haven asset as “. . . an asset that is uncorrelated or negatively correlated with another asset or portfolio in times of market stress or turmoil.” The latter condition, meaning a situation of widespread tension throughout the globe, is of primary importance to distinguish a haven-linked asset from others that usually serve as hedge vehicles. Indeed, for an asset to be seen as a hedge, it should show negative or no correlation at all with another portfolio on average, rather than only when markets experience turmoil. Thus, the key distinguishing feature between a hedge asset and a safe haven one is the length of the effect i.e., how long their inverse relationship with another asset or portfolio lasts.

It is worth pointing out the deeper distinction between strong and weak safe haven assets. While the former is strictly negative correlated with other assets or a portfolio, the latter is just uncorrelated with it in times of market turmoil. The distinction of a strong and weak safe haven is not only semantic but also important for investors. If an asset shows negative correlation with another asset or portfolio, investors enjoy positive returns if the other asset or portfolio exhibits (extreme) negative returns. This is not the case if the assets are just uncorrelated. Since positive returns of an asset during times of financial stress or turmoil can enhance the stability of the market by reducing overall losses, a distinction of weak and strong properties of the assets is then reasonably important (Baur and McDermott, 2010).

A recent research by Ji, Zhang and Zhao (2020) extends the definition of Baur and Lucey (2010) studying the dependence between different assets on left-tail quantiles (negative extremes) of their return distributions. Within their attempt to re-evaluate the safe haven role of some traditional assets during COVID-19 pandemic, the authors claims that safe havens' left tails should remain stable while those of risky assets widen during crisis, providing a different perspective of their expected inverse relationship.

The definition of Baur and Lucey (2010) is instead slightly modified by Hossfeld and McDonald (2015) who focus on currencies and qualify a safe haven as a currency whose effective returns are negatively related to global stock market returns in times of high financial stress, even after controlling for the impact of carry trades (or respectively, their reversal). This opens the path to a recurrent discussion in the literature, that of carry trade effect on safe havens determination. Previous empirical results suggest that low interest-currencies typically depreciate smoothly in "risk-on" episodes but appreciate abruptly in "risk-off" episodes (Brunnermeier et al., 2008, Burnside et al., 2011, as well as Gagnon and Chaboud, 2007, among others). But should all low interest currencies that appreciate in times of crisis be called "safe haven currencies"? While the appreciation of low interest currencies in times of crisis might be due to their perceived safe haven status, this pattern is also consistent with an unwinding of open carry trade positions, in which these currencies served as funding currencies[7]. In the view of Hossfeld and McDonald (2015), a "true" safe haven currency does not (only) appreciate because it served as a carry funding currency but because it is generally regarded as being safe by investors[8]. Hence, they control for the impact of carry trade reversals by including in their empirical model one-month interest rate spreads (carry trade strategies are normally of short-term, as found by Gagnon and Chaboud, 2007) in interaction with their indicator of financial stress. They find small but significant evidence of US dollar behaving as a safe haven, although the carry trade reversals factor is strongly significant too. De Bock and de Carvalho Filho (2015) argue instead that the interest rate effect has become substantially larger after 2007. According to the authors, the reason could

[7] When investors follow a carry strategy, they sell short a (low interest) funding currency and simultaneously buy a (high interest) target currency. This induces excess supply of the funding currency and excess demand for the target currency. In times of crisis, such a strategy might appear too risky to the investors and lead them to suddenly unwind their open positions, exerting sudden upward pressure on the funding currency.

[8] Similarly, Habib and Stracca (2012) claim that the concepts of safe haven currencies and carry funding currencies overlap only insofar as, and to the extent which, traders pursue carry trade strategies. Their findings confirm the notion that the interest rate differential is not a fundamental driver of safe haven status, and it depends on carry trade strategies being pursued (Kohler, 2010).

be that since the global financial crisis, cuts in G-3 policy rates have prompted many investors to increase their exposure to high-yield currencies which, in turn, have then depreciated more sharply during latest risk-off episodes. The unwinding of carry trades is also reported as being among the drivers of US dollar appreciation in 2008 (McCauley and McGuire, 2009). Nonetheless, the same research reinforces again the idea that funding and safe haven currencies have only low yields in common, but are far from being equivalent.

Coupled with the strand of literature specifically dealing with the relationship between the profitability of carry trade strategies and safe haven phenomena, there are other studies which have tried to go beyond this literature and establish what the real "fundamentals" of safe haven currencies are. In short, they address the question of what makes investors perceive a currency as a safe port in stormy financial conditions. In terms of economic fundamentals, Habib and Stracca (2012) find that the Net Financial Asset (NFA) position, which is an indicator of country risk and external vulnerability, is a consistent and robust predictor of safe haven status. To put it differently, the safe haven status may be related to the intrinsic risk profile of the country issuing the currency i.e., a country that is intrinsically less risky may be preferred in times of higher global risk aversion. In addition, they find self-fulfilling prophecies to play a consistent role in explaining currency returns during turbulent periods. In other words, currencies that have been in the past a good hedge to declining global stock markets and rising financial volatility are likely to remain a good hedge in the future too. Finally, Habib and Stracca (2012) report that the currencies of large economies, or with large financial markets, on a global scale, but less leveraged and less open to capital flows tend to have better safe haven properties in time of financial distress. De Bock and de Carvalho Filho (2015) find very similar results about the connection between safe haven behaviors and NFA positions, while they also claim that stronger current account balances are factors related to smaller risk-off depreciation or larger appreciation of a country's currency. Furthermore, they show that those currencies whose returns have a higher beta with respect to the AUDJPY exchange rate, which is popular with investors looking to implement G-10 carry trades, tend to have larger depreciations during markets turmoil.

Once the specific features of safe havens are properly identified, we can now turn the attention to the greenback. The literature picture here is quite mixed, due to conflicting points of view regarding the safe haven property of the USD. Besides the mentioned finding of Hossfeld and McDonald (2015), a couple of studies show some haven-linked appreciation of the Dollar. Nevertheless, these results are not a direct reflection of Dollar safety, but rather a consequence of other assets movements which inevitably affect the US currency. More precisely, the latter can either benefit from demand shocks for dollar-denominated safe assets such as US Treasuries (Jiang, Krishnamurthy and Lustig, 2020), or take advantage of devaluations in bilateral exchange rate pairs in which the greenback is the base (Habib and Stracca, 2012). In contrast, other publications about the behavior of currencies during risk-off episodes do not find significant evidence of the greenback behaving as a safe haven on its own (see, among the others, Ranaldo and Söderlind, 2010 or De Boch and De Carvalho Filho, 2015).

The cornerstone of this contradiction in findings could be the non-universality of an asset's safe haven role, as highlighted by different researches. In other words, the haven-linked behavior of a given asset may be market sensitive and be affected by divergent investors' characteristics as a result. As an illustration, Baur and McDermott (2010) provide empirical evidence gold playing a relatively minor role as a safe haven asset in emerging markets. Investors suffering losses in emerging market stocks may merely readjust their portfolios towards the average by withdrawing from emerging markets in favor of developed market stocks[9], rather than seeking an alternative haven asset.

Similar findings are made by Ji, Zhang and Zhao (2020) who, in addition, test whether safe haven features can change not only across markets, but also over time due to the different nature of the crisis triggering panic selling in financial markets. They find evidence that soybean futures have a strong and robust role in preserving value for an investment during the COVID-19 pandemic. Soy beans are a well fitted asset to test their hypothesis because food security has become a major issue for many countries, which makes agricultural commodities a strong hold under the current crisis. By the same token, Cheema, Faff and Szulzyk (2020) study the potential time changing properties of ten safe haven assets between the great financial crisis (GFC) and COVID-19, enriching the literature focusing on GFC as a crucial turning point for safe haven dynamics (see as an example De Bock and de Carvalho Filho, 2015). Even though their results, as well as those from Ji, Zhang and Zhao (2020), do not show significant evidence of a Dollar safe haven appreciation during the ongoing pandemic (while they do find such evidence for GFC), this topic still deserves further investigation. In fact, their findings might be of uncertain interpretation as long as their data only cover the period until mid-March 2020. On the contrary, as we unfortunately experienced over the course of time, that was only the very beginning of a much more resilient global health and economic crisis.

[9] This also reflects the contention of Calvo and Mendoza (2000) that investors worry not only about their absolute performance, but also about their performance relative to other investors.

The main contribution of this research is thus concerned with the extended sample period of which I make use. In other words, I analyze data collected all along the pandemic, until market conditions stabilized and investors uncertainty significantly fades as indicated, for example, by the VIX volatility index heading back to its pre-COVID "normal" levels. The next section looks closely also at the VIX while describing in details the empirical approach.

3. Methodology

In order to empirically test whether the USD acted as a safe haven during the COVID-19 pandemic, I implement a threshold regression model (Hansen, 2000). It allows the regression parameters to differ across two regimes depending on the value of a threshold variable, in this case the level of financial stress as measured by the VIX. Before I discuss the reasons for which the VIX is preferred to other measures of financial distress, it is worth noting how logically this model seems to fit with the features of safe havens. In particular, the fact that the haven-linked property of a given asset acquire relevance only in specific rather

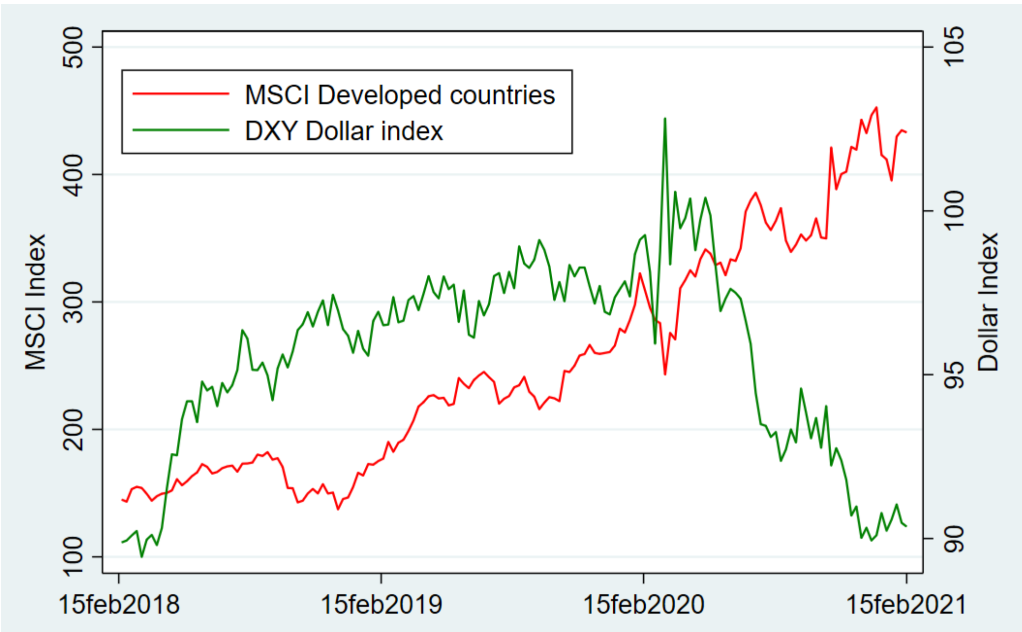

Fig. 1. The figure shows the evolution of a world stock index (MSCI Developed countries) and the DXY US Dollar index over a sub-sample period from 2018 until 2021 (weekly data). World index level is labelled on left vertical axis and DXY level is labelled on right vertical axis.

than all instances, meaning only when markets experience turmoil, leads quite straightforwardly to the setup of a non-linear approach like the threshold regression, by which it is possible to isolate the effect of global stocks movements during risk-off periods from that of normal times. Notably, the literature supports this kind of approach providing evidence of non-linear patterns for safe havens data in several cases (see Habib and Stracca, 2012, Ranaldo and Soderlind, 2010, De Bock and de Carvalho Filho, 2015, Hossfeld and McDonald, 2015, as well as Baur and McDermott, 2010).

A first illustration of non-linearity in the relationship between USD and MSCI world index can be found in **Fig. 1**, which presents a close look on both assets and shows how the relationship changes within three years (February 15, 2018 to February 15, 2021) from a positive to a negative relation. A least-squares regression of USD returns on world stock returns yields a tiny negative and significant coefficient for the sample shown in the figure. However, if we divide this period in two equal halves, it yields a flat and not significant coefficient for the first sub-sample period and a negative and significant coefficient for the

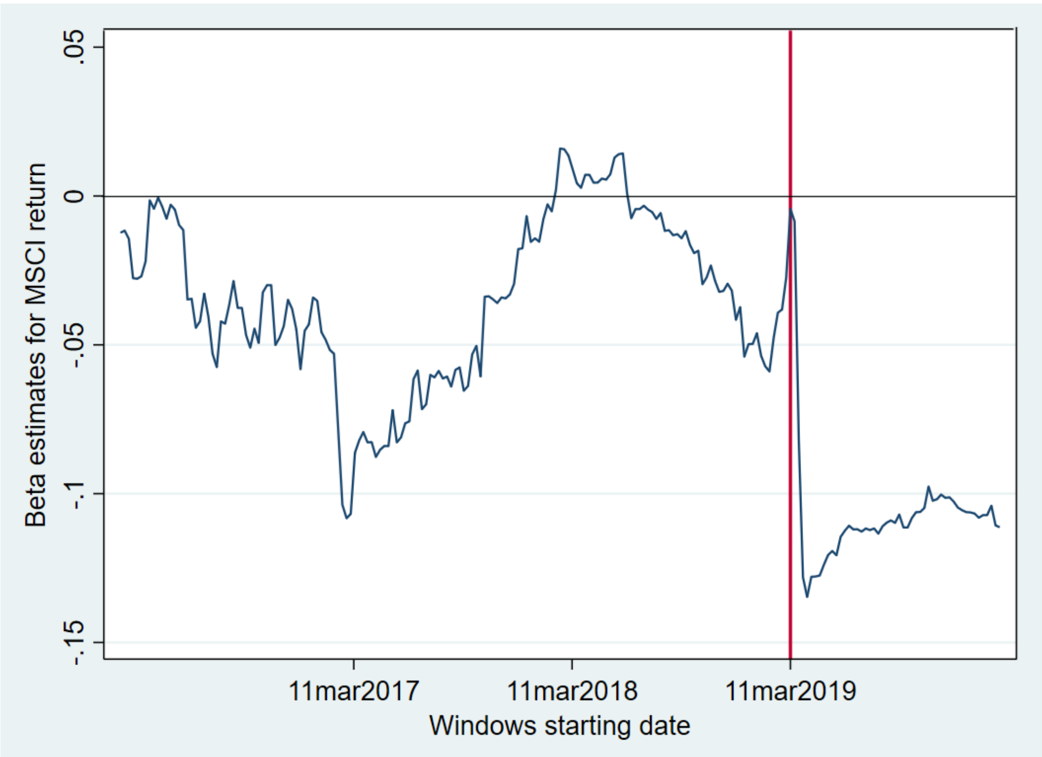

Fig.2. The figure presents the evolution of the correlation of the world stock market index with the USD based on weekly data. The rolling correlation estimates are based on a window length of 52 weekly observations and illustrate that the correlation is changing through time.

second sub-sample period, which is almost as double as that of the overall estimation in terms of magnitude[10]. This example shows that a flat or even positive beta on average does not exclude periods in which the USD temporarily acts as a safe haven.

In order to provide an additional and more precise representation of the USD time-varying behavior with respect to global stock markets, I present coefficient estimates of a rolling window regression of USD returns on the world portfolio index returns (similarly to Baur and McDermott (2010) in their investigation of gold and stocks co-movements). The window length is set to 52 weekly observations which approximately represents one calendar year. **Fig. 2** illustrates the coefficients (betas) for the world portfolio index. The time-varying betas confirm the hypothesis of a non-linear relationship. Since there are periods in which the beta is barely negative or even positive and periods in which it is decisively negative, this justifies the separation of the hedge property on average from that of a safe haven in specific periods. Moreover, it is worth remarking the evident presence of a quite precise threshold turning point. Indeed, the beta estimate sharply drops when the effect of the first shocking weeks in COVID-19 pandemic come into play.

For the purpose of this research, I make use of the VIX, a measure of U.S. equity market volatility that is widely used as a proxy for global risk aversion (also known as "fear index")[11], in order to identify this sudden shift in investor sentiment. De Bock and De Carvalho Filho (2015), referring to their choice of the VIX, argue that the latter presents three advantages. First, risk-off episodes derived from the VIX conform to prior studies about disruptive market events in the two decades preceding their research. Second, the VIX is available at high frequencies, so they state that the index can be used to identify the onset of risk-off episodes quickly. Third, since VIX is derived from options prices on the S&P 500, they identify a benefit in the fact that it does not directly draw on information from currency markets. Moving back to my threshold, it is interesting to note how the VIX jumps from a level of 17, all the way up to 40 in a matter of one week (the last of February 2020) when the COVID-19 disease surges for the first time. Furthermore, it never gets back below the level of 20 for the remaining year of data[12], and this is in clear contrast to the VIX average level in the four years prior to the end of February 2020 which was roughly 14.

[10] See tables A1 in the appendix for detailed estimation results.
[11] The VIX is derived from options prices on the S&P 500 index and informs us about volatility and risk pricing in the US equity market. The VIX is often given a broader interpretation, as it is highly correlated with broader measures of financial stress (such as the Financial Stress Index developed by the Federal Reserve Bank of St. Louis) and with bond market indicators, including spreads on sovereign bonds of emerging market countries. See also Table 2 of Habib and Stracca (2012) for further details.
[12] The minimum weekly observation is precisely 19,97.

For this reason, I chose at this point to define (somehow arbitrarily) the start of the risk-off pandemic driven period when the VIX goes beyond 20, and then focus on the 52 subsequent weeks[13]. Practically, I construct a dummy which takes the value of 1 whenever the VIX exceed the level of 20, and 0 otherwise. Subsequently, I regress USD returns on MSCI returns both individually and in interaction with the dummy just described. On the one hand, this is a very simple way to test whether the relation between USD and global stocks become significantly more negative conditional on the high level of financial distress; in other words, it shows if there is evidence of the non-linear relationship linking safe havens to global stock markets i.e., a negative correlation in financially distressed periods. On the other hand, a drawback of this model is that the threshold level for the VIX is set naively. Although this may be suitable when comparing results for different assets given the uniformity of the turmoil measure across all of those, it appears quite unjustified for my purpose which is to focus on potential USD safe haven features.

Here is where the threshold regression comes into play as a solution to this excessive arbitrariness issue. Indeed, such a model estimate the optimal threshold endogenously as the VIX value that minimizes the sum of squared errors function across both the low uncertainty and high uncertainty regimes. Once the threshold value is determined, the regression parameters are easily obtained by OLS[14].

Hence, the model I estimate is the following:

$$USDret_t = \alpha_r + \beta_r MSCIret_t + \gamma_r (i^*_{t-1} - i_{t-1}) + \varepsilon_t \qquad (1)$$

where the subscript r is either l (low) or h (high) according to the VIX being respectively below or above the threshold value which splits the sample into two regimes. $USDret_t$ is the continuously compounded USD return in period *t* as measured by the DXY Dollar Index and $MSCIret_t$ the compounded return on the MSCI developed world index in US dollars in period *t*. The term $(i^*_{t-1} - i_{t-1})$ is instead included in the model to control for the impact of

[13] I do not try to determine the end of the risk-off period. As claimed by De Bock and De Carvalho Filho (2015), episodes of high volatility may last from a few weeks to several months, and the transition from turmoil to more accommodating financial conditions is usually harder to pinpoint than the onset of a risk-off period.

[14] In my analysis, I make use of the fact that, conditional on the threshold value γ, the model is linear in the coefficients. The estimate of γ is the value of the VIX that minimizes the sum of squared errors function across both regimes. Once the threshold value is determined (i.e. γ is "concentrated out"), the regression parameters can be easily obtained by OLS. Subsequently, since inference on the threshold parameter γ is complicated because of its nonstandard asymptotic distribution, standard errors are derived from asymptotic theory and are robust to different kinds of misspecification. For a deep survey of threshold regression models in economics, refer to Hansen (2011).

carry trade reversals and represents the lagged effective interest differential: the variable denoted by an asterisk comes from a trade-weighted series calculated as the weighted average across interest rate series related to the currencies upon which the Dollar Index is constructed[15], while i_{t-1} refers to US rates[16]. Thus, if $\hat{\gamma}_r$ ends up being positive there would be evidence of USD serving as carry funding currency given that the higher the interest differential, the riskier it is for carry traders who therefore start unwinding their positions lifting back the funding currency (Brunnermeier et al., 2008).

Conversely, in order to classify the USD as a safe haven currency, $\hat{\beta}_h$ needs to be negative, signaling an inverse correlation between the currency and global stocks returns in times of high financial distress, as discussed in the previous section.

4. Data, analysis, and results

The sample period is from February 2016 to February 2021. Weekly observations (close price) for both DXY and VIX index are obtained from Yahoo Finance. I collect data on the MSCI world (advanced markets) index from Datastream. For the purpose of this research, weekly data is preferred to higher frequencies (like daily) but also to very low ones (like monthly), since there could be too much noise in the data which, in turn, would lead to potentially biased estimations (Baur and McDermott, 2010, Hossfeld and McDonald, 2015). Following the review of the existing literature (in particular, Gagnon and Chaboud, 2007, and Hossfeld and McDonald, 2015), I collect daily records for LIBOR 1-month money market rates from Datastream. Then, I take weekly averages for all currencies before constructing the trade-weighted series of foreign rates, as described in the previous section.

Table 1 presents key descriptive statistics of the log return series, as well as for the VIX and the effective interest differential. The table contains the number of observations, the mean, the standard deviation, the minimum and maximum values and the skewness and kurtosis for all the weekly data. The average weekly return of the world index is higher than the return of USD, but the standard deviation of the world index is larger too. This finding is also represented by the minimum and maximum values of the returns. MSCI index exhibits more extreme negative values (-15.35%) than the USD (-4.42%) and also more extreme

[15] See Table A2 in the Appendix for more information about trade weights used and the adjustments made.
[16] A similar proxy for carry trade reversals is used by Habib and Stracca (2012) and Hossfeld and McDonald (2015).

positive values (18.55% compared to 4.04% for the DXY index). A similar pattern can also be spotted in the skewness, which tells that both return series are fairly symmetric with the global stock returns having a slightly more pronounced right-handed tail. In either case, both return series are influenced by the abnormal movements, in both directions, typically reflecting very high uncertainty among market operators, like during turmoil times, as the kurtosis indeed indicate non-normal distributions with fat tails.

Table 1
The table presents the descriptive statistics of the world index and US Dollar continuously compounded returns and also the VIX index and the effective interest rate differential. The latter is calculated as the difference between a trade-weighted series of foreign rates and US rates. The statistics are based on weekly observations.

	Obs	Mean	St. Dev.	Min	Max	Skewness	Kurtosis
USD_ret	261	-0.03%	0.93%	-4.42%	4.04%	-0.0647	5.5525
MSCI_ret	261	0.69%	3.64%	-15.35%	18.55%	0.2775	7.1225
VIX	262	17.40%	8.52%	9.14%	66.04%	2.5800	12.2997
$(i^*_{t-1} - i_{t-1})$	262	-1.46%	0.75%	-2.88%	-0.24%	-0.0685	1.6072

I first examine the estimation results from the OLS regressions on global stock returns, both individually and in interaction with the dummy, which identify the exogenous VIX threshold level of 20. **Fig. 3** illustrates a scatterplots of USD returns (vertical axis) vs. MSCI index returns (horizontal axis) conditional on the high-stress regime (VIX exceeds 20), while the estimation results are presented in **Table 2.** These results are consistent with the hypothesis of USD acting as a safe haven over the sample period. The coefficient estimate for the interaction term (column (2)) is in fact negative and significant while that of global stock returns alone is not. This shows that the negative correlation between the USD and global equity is predominantly due to the greenback being perceived as a safe port during market storms rather than acting as a hedge asset on average. The specification in column (3) also controls for the impact of carry trades. In contrast with the findings of Hossfeld and McDonald (2015), the term controlling for carry trade reversals in risk-off periods (in this case the lagged interest differential in interaction with the threshold dummy) yields a not significant coefficient, while the estimate of interest (global stock returns in interaction with the threshold dummy) is almost unchanged and still strongly significant.

Moving to the threshold regression approach, **Table 3** presents and compares results from the separate estimations of the two models. The first comes from a more parsimonious specification, which includes only global stock returns. The second model controls for lagged interest differential, too. The results effectively point towards the existence of two distinct regimes. Interestingly, the endogenously determined VIX thresholds levels appear to be very close to the one exogenously chosen in the former approach. To put it differently, the threshold levels for the parsimonious and the extended specification are respectively 21.56 and 24.52 i.e., as far as 4 points at maximum from the naïvely identified level of 20. The levels imply that about 21% and 15%, respectively, of all the observations fall into the high-stress regime for the two specifications.

As indicated in the previous section, the USD is classified as a safe haven asset if $\hat{\beta}_h < 0$. According to the estimation results, the latter condition is effectively met. The coefficient estimate for MSCI_ret is by no means significant in the low-stress regime, but the impact of global stock market returns increases noticeably in the high-stress regime. In the latter, a 1

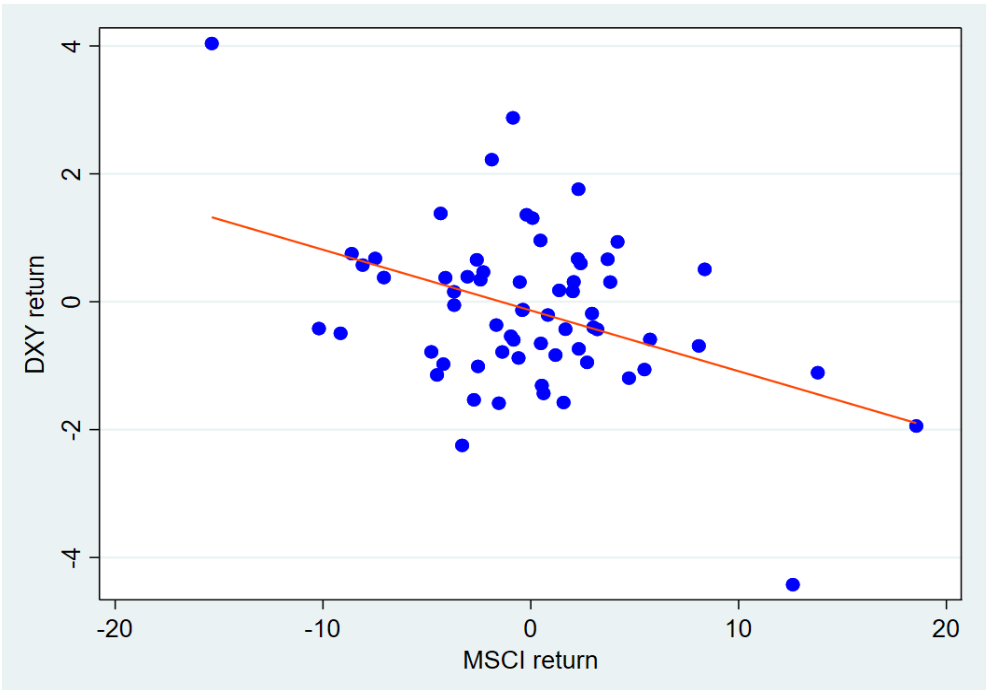

Fig. 3. The figure illustrates a scatterplots of USD returns (vertical axis) vs. MSCI index returns (horizontal axis) conditional on the high-stress regime, meaning when the VIX is above 20. A linear prediction line is also shown.

Table 2
The table presents OLS estimation results for USD returns on global stock market returns as measured by the MSCI advanced markets index. 'VIX20' is a dummy equal to 1 if the VIX index exceed 20 and 0 otherwise. '$(i^*_{t-1} - i_{t-1})$' is the effective interest differential, calculated as the difference between a trade-weighted series of foreign rates and US rates.

	(1) USD_ret	(2) USD_ret	(3) USD_ret
MSCI_ret	-0.0624***	-0.0230	-0.0296
	[0.0154]	[0.0227]	[0.0231]
MSCI_ret*VIX20		-0.0718**	-0.0672**
		[0.0306]	[0.0313]
$(i^*_{t-1} - i_{t-1})$			-0.0717
			[0.0757]
$(i^*_{t-1} - i_{t-1})$*VIX20			0.123
			[0.106]
Constant	0.0175	-0.0104	-0.0838
	[0.0569]	[0.0576]	[0.125]
Observations	261	261	261
R-squared	0.060	0.080	0.087

Note: Standard errors in brackets.
***, **, and * denote significance levels of 1%, 5%, and 10%, respectively.

percentage point (pp) increase (decrease) in global stock market returns is associated with 0.11 pp decrease (increase) in USD returns (significant at 1% level). Notably, the magnitude of the effect almost doubles from the OLS approach with the threshold dummy, where a 1 pp increase (decrease) in global equity returns is at most associated with 0.07 pp decrease (increase) in USD returns and "only" significant at 5% level.

The reason for coefficients reported in **Tables 2–3** to be relatively small (they lie in the interval [-0.12, -0.02]), could be the time-variation in the USD–stocks relationship as described and reported above. An explicit analysis of shorter periods, e.g. a strong bull or bear market leads to larger absolute coefficients. In fact, the plot of the time-varying beta estimates presented above shows that the betas are larger in absolute terms for sub-periods of 52 weeks (the maximum absolute value is 0.14). These episodes also include bull and bear markets. However, I do not analyze such market trends since it is to some extent more difficult to identify bull and bear markets and to distinguish such periods from each other rather than identify high- and low-stress periods (Baur and McDermott, 2010).

Table 3
The table presents threshold regressions estimation results for USD returns on global stock market returns as measured by the MSCI advanced markets index. Stress regimes are specified in the first row, in correspondence of VIX_t variable, and according to the endogenously determined threshold levels for both models. '$(i^*_{t-1} - i_{t-1})$' is the effective interest differential, calculated as the difference between a trade-weighted series of foreign rates and US rates.

	(1)	(2)	(3)	(4)	(5)	(6)
	USD_ret	USD_ret	USD_ret	USD_ret	USD_ret	USD_ret
VIX_t	Any	≤ 21.56	> 21.56	Any	≤ 24.52	> 24.52
MSCI_ret	-0.0624***	-0.0236	-0.108***	-0.0626***	-0.0292*	-0.119***
	[0.0154]	[0.0190]	[0.0291]	[0.0153]	[0.0171]	[0.0385]
$(i^*_{t-1} - i_{t-1})$				-0.102	-0.103	0.111
				[0.0747]	[0.0743]	[0.362]
Constant	0.0175	0.0255	-0.139	-0.132	-0.153	0.0526
	[0.0569]	[0.0577]	[0.160]	[0.123]	[0.128]	[0.377]
Observations	261	206	55	261	223	38
R-squared	0.060	0.008	0.205	0.067	0.020	0.215

Note: Standard errors in brackets.
***, **, and * denote significance levels of 1%, 5%, and 10%, respectively.

Additionally, two other results are noteworthy. Firstly, although sign and size of the carry trade term coefficient suggest that carry trades in which the USD serves as a funding currency are unwound in times of high financial distress, the coefficient is, as in the previous OLS approach, not only insignificant by far (p-value = 0.36), but also irrelevant for the MSCI_ret estimate. In fact, quite surprisingly, the latter is even slightly more negative in this case (-0.12 versus -0.11 before), while still significant at 1% level. Secondly, the explanatory power of both models increases considerably from the low- to the high-stress regime. In the low-stress regime, just around 1% of USD returns can be explained by the first model, while around 20% of its returns can be explained by the model if the VIX is above its threshold value of 21.56. Almost the same is observed in the extended specification.

Together, all these results suggest that the USD is a strong safe haven asset during the COVID-19 pandemic, in contrast with the findings of Cheema, Faff and Szulzyk (2020) and Ji, Zhang and Zhao (2020). Notwithstanding, these results do support their hypothesis of non-universality of safe haven properties, as a consequence of the different nature of crisis triggering financial markets turmoil.

5. Conclusions

Searching for safe-haven assets is a timely and important issue under the current COVID-19 pandemic. The profound impact of this health crisis has caused investors all over the world to suffer great losses, and thus, the demand for safe-haven assets has become even greater. Currencies which are traditionally candidates for a safe haven role may lose some effectiveness given the unique nature of the current crisis. Therefore, their role as safe haven assets must be re-evaluated.

In this thesis I tested the hypothesis that the USD acts as a safe haven asset during the latest pandemic. I define a currency as a safe haven if it benefits from negative exposure to global stock returns when markets experience turmoil, while at the same time I point out the distinction between a weak and strong form of the safe haven effect. A weak safe haven will protect investors to the extent that it does not move in tandem with other assets in response to negative market shocks. The strong safe haven, by moving against other assets during periods of market stress, reduces overall losses for investors when it is most needed. Furthermore, the use of DXY effective exchange rate returns (as opposed to bilateral returns) allows me to gauge whether the USD can be regarded as a safe haven currency in absolute terms, which is what we should really think of when speaking of a "safe haven currency", as well as to overcome the problem that two similar safe haven currencies "cancel each other out" in the numerator and the denominator of a bilateral exchange rate.

I first regress DXY Dollar Index returns on global stock returns as measured by the MSCI Developed Countries index, both individually and in interaction with a threshold dummy identifying distressed periods using the VIX as a proxy for the level of financial stress. I find that the USD acts as a strong safe haven during COVID-19, protecting investors from stock market losses. I also use the threshold regression approach (Hansen, 2000) to check the robustness of my empirical findings. The results are not only largely consistent, but also stronger in the latter approach where the VIX threshold level is determined endogenously in the model. The results also hold after controlling for the unwinding of carry trades in which the USD might have served as carry funding currency, showing that it appreciates mainly because it is regarded as being safe by investors.

Two other facts are worth noting. First, this study enriches the literature on safe havens by providing further evidence of asymmetry and non-linearity in safe haven behaviors: the results from threshold models do point towards the existence of two distinct regimes, and the safe haven effects indeed appear to show up in crisis periods and after positive shocks to global risk aversion. Secondly, outdistancing from the previous mixed and uncertain evidence on the haven-linked property of the greenback, my findings of a strong USD safe haven behavior during COVID-19 in developed world markets contribute to the ongoing discussion that the safe haven role of a given asset may be sensitive to changes over time and across markets. While the former is likely due to the different nature of shocks triggering each time a sudden shift in investors' sentiment, the latter refers to hypothesis that investors suffering losses in emerging market stocks, rather than seeking an alternative haven asset, may merely readjust their portfolios towards the average by withdrawing from emerging markets in favor of developed market stocks.

My findings are useful for investors and fund managers searching for a strong and liquid safe haven, such as the USD, to offset large stock market losses. Furthermore, these findings could be helpful to policymakers in the US. Knowing whether its own currency is likely to appreciate or depreciate in future risk-off episodes is useful information for policymakers interested in the consequences of risk-off episodes for monetary policy and asset management. In a country where the local currency is regarded (globally) as a safe haven asset, risk-off episodes bring on challenges related to rapid currency appreciation, such as loss of export competitiveness and deflation risks.

The analysis conducted in this paper is in-sample. A useful and very interesting extension of my work would be to test whether it is possible to predict safe haven behavior out of sample. Based on information up to time $t-1$, can a trader predict to what extent a currency will appreciate if global volatility goes up by x%? Moreover, a greater challenge is to understand the real drivers of the safe haven phenomenon. How and to what extent safe haven effects originate from capital flows looking for reassuring political and economic environments, flight-to-quality/liquidity dynamics and the intrinsic risk profile of the country issuing the currency are questions left for future research.

Appendix

Table A1
The table presents OLS estimation results for USD returns on global stock market returns as measured by the MSCI advanced markets index for the period mid-February 2018 through mid-February 2021. Column (1) presents results for the whole period, while columns (2) and (3) present coefficient estimates for two sub-periods.

	(1) USD_ret	(2) USD_ret	(3) USD_ret
Estimation period	2018-02-12/ 2021-02-15	2018-02-12/ 2020-02-10	2020-02-17/ 2021-02-15
MSCI_ret	-0.0652***	-0.0110	-0.111***
	[0.0166]	[0.0181]	[0.0294]
Constant	0.0543	0.111*	-0.113
	[0.0715]	[0.0648]	[0.160]
Observations	157	104	53
R-squared	0.090	0.004	0.217

Note: Standard errors in brackets.
***, **, and * denote significance levels of 1%, 5%, and 10%, respectively.

Table A2
The table presents the weight vector used for calculation of the trade-weighted series of foreign rates i_{t-1}^*. These are the same weights used for construction of DXY Dollar Index.

	EUR	GBP	JPY	CAD	SEK	CHF
i_{t-1}^*	0.58	0.12	0.14	0.09	0.04	0.04

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