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Libra or Librae? Basket based stablecoins to mitigate foreign exchange volatility spillovers*

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ABSTRACT

The paper aims to assess, from an empirical viewpoint, the advantages of a stablecoin whose value is derived from a basket of underlying currencies, against a stablecoin which is pegged to the value of one major currency, such as the dollar. To this aim, we first find the optimal weights of the currencies that can comprise our basket. We then employ volatility spillover decomposition methods to understand which foreign currency mostly drives the others. We then look at how the stability of either stablecoin is affected by currency shocks, by means of VAR models and impulse response functions. Our empirical findings show that our basket based stablecoin is less volatile than all single currencies. This results is fundamental for policy making, and especially for emerging markets with a high level of remittances: a librae (basket based stable coin) can preserve their value during turbolent times better than a libra (single currency based stable coin).

JEL classification: C01, C32, C58, G21, G32
Keywords: Cryptocurrencies; Fintech; Stablecoins; Spillover; Variance decomposition.

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I. Introduction

Carney (2019) posed the question of whether a Synthetic Hegemonic Currency (SHC) would be best provided by the public sector. The rationale would be that a global currency, underpinned by a basket of reserve assets, could better support global outcomes. For example, an SHC could dampen the dominating influence of the US dollar on global trade, it could alleviate spillovers to exchange rates from shocks to the US economy, and trade across countries could become less dependent on the dollar.

This is not the first time that the idea of global currency has been floated publicly. Cooper (1984) advocated for a *radical alternative scheme for the next century: the creation of a common currency for all of the industrial democracies, with a common monetary policy and a joint Bank of Issue to determine that monetary policy.* On the other hand, others have argued in favour of retaining major currencies but with a tighter exchange rate policy among them (Williamson, 1993; McKinnon et al., 1984). Or in maintaining the status quo as suggested by Rogoff (2001).

The revival of discussions concerning an SHC, have somewhat been sparked by the discourse surrounding central bank digital currency (CBDC) and stablecoins. In particular, Facebook announced plans for its own privately issued stablecoin that could emulate some of the characteristics of an SHC. The proposition is to construct a stablecoin that can circulate globally with a value that is derived from an underlying basket of assets comprised of the major currencies.[1] Whilst the exact composition of the underlying basket of assets is yet unspecified, the objective is to devise a digital currency whose exchange rate fluctuations are minimised against several currencies. These plans have been met with resistance from regulators and Facebook itself has repeatedly stated that the Libra stablecoin could be backed by a single currency (the dollar).

Why have regulators reacted with such caution to Facebook's plans to issue a stablecoin? Firstly, as a tech-giant Facebook can push Libra to its vast user-base, approximately 2.41 billion monthly active users.[2] To put this into perspective, currently it is estimated there around 40 million bitcoin wallets and 1 million daily users.[3] [4] Facebook would have to successfully penetrate 2% of its user base to match what is an upper bound on a proxy for the size of bitcoins user base, the most commonly used cryptoasset. Whilst the two assets may serve different purposes, there is potential for Facebook's Libra to rapidly acquire a significant user base transacting in a privately issued global digital currency. This may affect significantly, in particular, private individuals' transfers of money from remittances.

A remittance is a transfer of money made by a foreign worker to an individual in its home country. Remittances are one of the largest capital flows to developing countries. According to the World Bank, in 2018 overall global remittance grew 10% to 689 billion dollars, including 529 billion dollars to low income countries. India consecutively remains the top receiver of remittances, with 80 billion dollars in 2018 (about 3% of India's GDP), followed by China, the Philippines, Mexico and Nigeria.[5] While in the

[1] See https://libra.com
[2] https://newsroom.fb.com/company-info/
[3] The number of bitcoin wallets: https://www.statista.com/statistics/647374/worldwide-blockchain-wallet-users/
[4] The number of active wallets: https://coinmetrics.io/.
[5] https://www.knomad.org

past the remittance industry has been dominated by few financial players (such as Western Union), with a high transaction cost, recently many fintech startups (such as TransferWise) have entered the market with competitive offers, opening the door to the possible entrance of bigtechs such as Facebook, with its Libra project.

Against this background, we investigate the consequences of a global SHC (”Librae”, in a literal sense), regardless of whether issued by a private company such as Facebook, or by a central bank. In particular, we compare the stability of an SHC to that of a single currency based currency (”Libra”, in a literal sense). To this aim we first look at the optimal design of an SHC that is backed by a basket of underlying reference currencies, such as those included in the International Monetary fund Special Drawings Rights (SDRs), and compare the resulting volatility with that of single currencies, from 2002 onwards. We then study the currencies which mostly determine volatility spillovers among exchange rates, using the framework of Diebold and Yılmaz (2014). Based on the previous results, we then proceed to assess, by means of VAR based impulse response functions, the impact that shocks on the driving currencies would carry on the SHC or on single currencies, to understand which stablecoin design (Libra or Librae) better preserves the value of remittances from low income countries. For the optimal construction of a basket of currencies, we follow Hovanov et al. (2004) to compute a minimum variance currency basket using major currencies. We construct a reference basket that contains the Dollar (USD), the Euro (EUR), the Yen (JPY), the Renminbi (CNY) and the Pound Sterling (GBP), the currencies employed for the determination of the IMF's Special Drawing Rights (SDR) basket. The weights are determined applying Markowitz' portfolio allocation algorithm on daily data from January 2002 up until November 2019. We compare the obtained weights with those of the SDR. Our empirical findings show, in particular, that our basket puts less weight in the dollar, and more weight on the Euro and on the Renminbi.

By construction, our basket based currency should be the least varying in comparison to those contained in the basket, and our results confirm this. However, it is of interest to see how the SHC fares against currencies outside of the basket, for example against the currencies of the most important remittance markets. The comparison can answer a very important question, that is: is the exchange rate of the SHC less volatile then the exchange rate of the dollar and, consequently, of a dollar-based stablecoin? To answer this question, we recompute the currency invariant indices with the inclusion of additional currencies, namely the Indian Rupee, the Mexican Peso, the Philippine Peso ad the Nigerian Naira. Our empirical findings show that, overall, the SHC has the lowest volatility and, therefore, remittances converted in SHC best maintain their value. A basket based stablecoin, based on the IMF Special drawing rights, performs almost as well. A dollar based stablecoin, instead, performs worse, with the exception of during the crisis times.

Our volatility spillover decomposition shows that the dollar is the currency that has the largest impact on the others, especially in terms of exporting contagion. As a consequence, a shock on the dollar, expressed by a one standard deviation decrease in its normalised value with respect to the other currencies, causes a shock on all currencies and, through high order contagion, on the dollar itself, leading to a new lower equilibrium. Differently, a shock in the value of the SHC, caused by a shock of a currency in the basket, is offset by the diversification effect and, therefore, the starting equlibrium is maintained. This implies that remittances converted in basket based stablecoin better maintain their value, with respect to those converted in dollars (or dollar based stable coins).

The rest of the paper is organised as follows, Section II contains a review of the relevant literature, Section III outlines our proposed methodologies, Section IV presents our data and the empirical findings, and finally in Section V we conclude.

II. Literature Review

A. Stablecoins and e-money

We take the definition of a 'stablecoin' to be a crypto-asset designed to maintain a stable value relative to another asset (typically a unit of currency or commodity) or a basket of assets (Financial Stability Board, 2019). Bullmann et al. (2019) make the following distinctions between types of stablecoins.

- **Tokenised funds** - denote stablecoins that are a claim on a pool of collateral that consists of funds, including cash, electronic money, commercial bank money or central bank reserve deposits e.g. Tether, Utility Settlement Coin
- **Off-Ledger Collateralised** - stablecoins that are a claim on a pool of collateral that is comprised of various assets e.g. multiple currencies, T-Bills etc
- **On-Ledger Collateralised** - stablecoins that are a claim on a pool of underlying collateral that is held on a blockchain e.g. Dai
- **Algorithmic** - take users expectations into account to stabilise the value of the coin (mostly conceptual) e.g. BasisCoin

At present, tokenised funds and off-ledger collateralised are the most common occurring instances of stablecoins. Libra, would fall into the later as the foundation has plans to invest the funds that are received in return for stablecoins. From herein, we work with two instances of a stablecoin, the Libra, in which single-currency stablecoins are issued in receipt of funds, this is essentially the tokenised funds model. The other instance, Librae, would have its own exchange rate that is backed by a basket of currencies, this would fall into the off-ledger collateralised category as the foundation intends to invest the funds across currencies and potentially in other interest yielding assets.

This is not the first time that electronic money has been on the agenda for central banks and policy makers, after a flurry of innovations in this space, in 1996 and 1998 respectively the BIS and ECB published reports addressing the regulation of e-money and the implications for monetary policy.[6] For various reasons, these forms of e-money never really troubled the concerns of policy makers of the time.[7]. However, discussions around digitised forms of money have reared their head once again.

[6] See European Central Bank (1998); Bank for International Settlements (1996)
[7] For example, see Levene (2006)

B. Global currencies

Keynes originally suggested the *bancor* as a unit of account of his proposed International Clearing Union, intended to fix to the dual dollar gold system. His plan for the international monetary system was put up against those of Dexter White. After ongoing negotiations between the United States and the United Kingdom the International Monetary Fund (IMF) was eventually established. The IMF then approved the Special Drawing Rights (SDRs) in 1967. The IMF's issuance of SDRs could be seen as a supranational currency issued by central banks, although the SDR does not fulfil all functions of money. Whilst serving as a store of value and unit of account, SDRs are only used by some central banks and international institutions as a means of exchange to pay each other (Ocampo, 2019). For this, they may not be strictly considered as a“true” global currency.

A boost to the importance of SDRs was given in 2009, when China called for reforms to the international monetary system by adopting the SDR as a reserve asset. Against these developments, Humpage (2009) suggests that while the adoption of the SDR as a reserve asset is technically feasible, it would not reduce the dollar's role any time soon. Many foreign-exchange transactions, even excluding US residents, are denominated and settled in dollars. Producers typically invoice their products in dollars, which keeps their prices in line with their competitors and simplifies cross-border price comparisons among producers (Gopinath et al., 2016).

Given the persistent importance of the US dollar, the question is whether this will remain so under the fintech transformation that is changing the financial world. And, in particular, whether a dollar based stable coin is more likely to be adopted than a basket based one.

C. Remittances and exchange rates

A stablecoin backed by a basket of currencies could be an attractive asset for foreign workers that make remittances to families in their home countries. In particular where its value is not directly tied to the domestic currency. Under the status quo, an appreciation in the value of the domestic currency can reduce the remittances ratio because workers want to to keep the additional earning from the appreciation of the currency. On the other hand, workers based in foreign countries, where the value of the domestic currency is declining, may remit money on an urgent basis.

These remittances also have an effect on the receiving countries. One specific challenge for countries that face large inflows of worker remittances could lead to the emergence of ”Dutch disease,” that is, remittance inflows could result in an appreciation of the equilibrium real exchange rate that would tend to undermine the international competitiveness of domestic production, particularly that of nontraditional exports. BARAJAS et al. (2011) note that reasonable modifications in the modelling of the factors driving remittances, or in the various macroeconomic roles that remittances may play, could moderate or even reverse the expected impact of remittance flows on the equilibrium value of the real exchange rate.

Acosta et al. (2009a) discuss two mechanisms by which this occurs, the first mechanism is demonstrated in the Salter-Swan-Conder-Dornbusch model, whcih points to a “spending effect,” by which the increase in wealth following higher capital inflows from remittances, combined with exogenous tradable prices, causes the prices of nontradable goods and services to rise. These higher prices lead to an expansion in the nontradable sector. By definition, an increase in the price of nontradables relative to the price of tradables translates into real exchange rate appreciation.

The second mechanism, proposed in Acosta et al. (2009b), is that remittances tend to increase household aggregate wealth. An increase in household wealth may lead to a decrease in labor supply as households substitute more leisure for work. A shrinking labor supply, in turn, puts upward pressure on wages. Rising wages raise production costs, and higher production costs can lead to a further contraction of the tradable sector. Both the resource reallocation effects and the labor effects can cause an appreciation of the exchange rate, thereby reducing the international competitiveness of the tradable sector, and may lead to tradable sector contraction, higher wages, and higher production costs.

A basket based currency could dampen some of these effects as it is less susceptible to appreciation and depreciation of the domestic and foreign currencies. However, the effects are likely to be ambiguous and depend on how the stablecoin is used. If it gains acceptability in the home currency this could leads to new episodes of dollarisation, whereas if the currency is only used as a medium of exchange the effect could be negligible.

D. Contribution of the paper

The paper combines the background of the previous streams of literature, namely: the need of a global currency, which is "optimal" in terms of minimum volatility (maximum stability), and resilient to exchange rate shocks; with the emergence of fintech technologies, and of blockchain based stable coins in particular.

Within this background, we contribute to the previous literature, from an economic viewpoint, by answering the following research question: is a basket based stable coin better than a single currency one, in terms of stability?

To answer the previous question, we contribute to the literature, from a methodological viewpoint, with three main innovations: i) we provide a methodology to build a minimum variance basket of currency, statistically deriving the optimal weights; ii) we provide a methodology aimed at assessing contagion spillovers among foreign exchange markets, based on Diebold and Yilmaz variance decomposition model; iii) we provide a VAR based methodology to build impulse response functions aimed at assessing the long run impact of a currency shock on both a basket based and a single currency based stable coin.

III. Methodology

In this section we outline the methodologies employed in our empirical application. Firstly, we describe the optimal control problem which yields to the optimal stablecoin weights. Secondly, we introduce our VAR model and, based on it, we study the spillover effects across the currencies in the basket to determine their interconnectedness and, therefore, to understand which are the most relevant ones in terms of shock transmission. Thirdly, using again the proposed VAR model, we analyze the impact of shocks in the currencies within the basket on the other currencies and, consequently, on the stablecoins.

A. *Optimal control problem*

We aim to build a basket of predetermined (reference) currencies with optimal weights, namely, weights which minimize the variability of a basket based stablecoin. This translates into an optimal control problem which minimize the variance of the basket constructed with the above mentioned currencies.

Hovanov et al. (2004) show that the values of any given currency depends on the base currency chosen. The latter fact creates ambiguity in evaluating the currency itself and its dynamics. To overcome this issue,Hovanov et al. (2004) proposed a reduced (to the moment t_0) normalized value in exchange (RNVAL) of the i-th currency:

$$\mathrm{RNVAL}_i\left(t/t_0\right) = \frac{c_{ij}(t)}{\sqrt[n]{\prod_{k=1}^{n} c_{kj}(t)}} \Big/ \frac{c_{ij}\left(t_0\right)}{\sqrt[n]{\prod_{k=1}^{n} c_{kj}\left(t_0\right)}} = \sqrt[n]{\prod_{k=1}^{n} \frac{c_{ik}(t)}{c_{ik}\left(t_0\right)}} \tag{1}$$

By reducing to the moment t_0 and normalizing each currency observation by the geometric average of the other currencies at that specific point in time, the RNVAL allows the computation of a unique optimal, minimum variance currency basket, despite the base currency choice. The minimum variance currency basket is derived by searching the optimal weight vector w^* which solves the following optimal control problem:

$$\mathrm{Min}\left(S^2(w) = \sum_{i,j=1}^{n} w_i w_j \operatorname{cov}(i,j) = \sum_{i=1}^{n} w_i^2 s_i^2 + 2\sum_{i,j=1}^{n} w_i w_j \operatorname{cov}(i,j)\right) \tag{2}$$

subject to

$$\begin{cases} \sum_{i=1}^{n} w_i = 1 \\ w_i \geq 0 \end{cases}$$

The optimal control problem in Equation (2) yields to the minimum variance weights which enable us to construct the stablecoin value.

B. *VAR models and spillover analysis*

We evaluate spillovers through the methodology by Diebold and Yilmaz (2012). As in their seminal paper, we start from estimating a Vector AutoRegressive (VAR) model, that is :

$$x_t = \sum_{i=1}^{k} \Phi_i x_{t-i} + \varepsilon_t \tag{3}$$

where x_t being the $(n \times 1)$ vector of first differences in RNVALs at time t, Φ_i the $(n \times n)$ VAR parameter matrices, k the autoregressive order, ε_t a zero-mean white noise process having variance-covariance matrix Σ_ε, with n being the number of currencies considered in order to build the basket. Note that the VAR model is built on the variables' first differences, as this ensure the stationarity of the analyzed time series.

The VAR in Equation 3 may also be rewritten in its corresponding vector moving average (VMA) representation, that is

$$x_t = \varepsilon_t + \Psi_1 \varepsilon_{t-1} + \Psi_2 \varepsilon_{t-2} + \cdots \tag{4}$$

where $\Psi_1, \Psi_2, \ldots$ the $(n \times n)$ are the matrices of VMA coefficients. The VMA coefficients are recursively computed as $\Psi_i = \Phi_1 \Psi_{i-1} + \Phi_2 \Psi_{i-2} + \ldots + \Phi_i \Psi_1$, having $\Psi_i = 0 \; \forall i < 0$ and $\Psi_1 = I_n$.

As it is widely accepted in the financial econometric literature, the variance decomposition tools are used to evaluate the impact of shocks in one system variable on the others. Strictly speaking, variance decompositions decompose the H-step-ahead error variance in forecasting x_i which is due to shocks to x_j, $\forall j \neq i$ and $\forall i = 1, \ldots, n$.

In this paper we make use of the KPPS H-step-ahead forecast error variance decompositions, as Diebold and Yilmaz (2012) do. This is because we avoid imposing an a priori ordering exchange rates regarding the influence of shocks across the system variables, as popular techniques like the Cholesky identification scheme do. Indeed, the KPPS H-step-ahead forecast errors have are convenient as they are invariant with respect to the variable ordering.

As already stated, Diebold and Yilmaz (2012) found their methodology on the H-step ahead forecast error variance decomposition. Considering two generic variables x_i and x_j, they define the own variance shares as the proportion of the H-step ahead error variance in predicting x_i due to shocks in x_i itself, $\forall i = 1, \ldots, n$. On the other hand, the cross variance shares (spillovers) are defined as the H-step ahead error variance in forecasting x_i due to shocks in x_j, $\forall i = 1, \cdots, n$ with $j \neq i$.

In other words, denoting as $\theta^g_{ij}(H)$ the KPPS H-step forecast error variance decompositions, with $h = 1, \cdots, H$, we have:

$$\theta^g_{ij}(H) = \frac{\sigma_{jj}^{-1} \sum_{h=0}^{H-1} (e_i' \Psi_h \Sigma e_j)^2}{\sum_{h=0}^{H-1} (e_i' \Psi_h \Sigma \Psi_h' e_i)} \tag{5}$$

with σ_{jj} being the standard deviation of the innovation for equation j and e_i the selection vector, i.e. a vector having one as i^{th} element and zeros elsewhere. Intuitively, the own variance shares and cross variance shares (spillovers) measure the contribution of each variable to the forecast error variance of itself and the other variables in the system, respectively, thus giving a measure of the importance of each variable in predicting the others.

Note that the row sum of the generalized variance decomposition is not equal to 1, meaning $\sum_{h=0}^{H-1} \theta^g_{ij}(H) \neq$

1. Diebold and Yilmaz (2012) circumvent this problem by normalizing each entry of the variance decomposition matrix by its own row sum, i.e.

$$\tilde{\theta}^g_{ij}(H) = \frac{\theta^g_{ij}(H)}{\sum_{j=1}^n \theta^g_{ij}(H)} \tag{6}$$

This tackles the above mentioned issue and yields to $\sum_{j=1}^n \tilde{\theta}^g_{ij}(H) = 1$, and $\sum_{j,i=1}^n \tilde{\theta}^g_{ij}(H) = n$.

As a measure of the fraction of forecast error variance coming from spillovers, Diebold and Yilmaz (2012) define the total spillover index (TSI):

$$TSI(H) = \frac{\sum_{\substack{j=1 \\ j\neq i}}^n \tilde{\theta}^g_{ij}(H)}{\sum_{j,i=1}^n \tilde{\theta}^g_{ij}(H)} \cdot 100 = \frac{\sum_{\substack{j=1 \\ j\neq i}}^n \tilde{\theta}^g_{ij}(H)}{n} \cdot 100 \tag{7}$$

Moreover, we also make use of directional spillovers indexes (DSI) to measure, respectively through equations (8) and (9), the spillover from exchange i to all other exchanges J (cfr. Eq. 8) and the spillover from all exchanges J to exchange i (cfr. Eq. 9) as:

$$DSI_{J\leftarrow i}(H) = \frac{\sum_{\substack{j=1 \\ j\neq i}}^n \tilde{\theta}^g_{ji}(H)}{\sum_{j,i=1}^n \tilde{\theta}^g_{ij}(H)} \cdot 100 \tag{8}$$

$$DSI_{i\leftarrow J}(H) = \frac{\sum_{\substack{j=1 \\ j\neq i}}^n \tilde{\theta}^g_{ij}(H)}{\sum_{j,i=1}^n \tilde{\theta}^g_{ij}(H)} \cdot 100 \tag{9}$$

Directional spillovers may be conceived as providing a decomposition of total spillovers into those coming from - or to - a particular variable. In other words, they measure the fraction of forecast error variance which comes from (or to) one of the variables included in the system - and, hence, the importance of the variable itself in forecasting the others. From the definitions of directional spillover indexes, it is natural to build a net contribution measure, impounded in the net spillover index (NSI) from market i to all other markets J, namely:

$$NSI_i(H) = DSI_{J\leftarrow i}(H) - DSI_{i\leftarrow J}(H) \tag{10}$$

Another very important metric to measure the difference between the gross shocks transmitted from market i to j and gross shocks transmitted from j to i is the net pairwise spillover (NPS), defined as:

$$PNS_{ij}(H) = \left(\frac{\tilde{\theta}^g_{ij}(H)}{\sum_{q=1}^{n} \tilde{\theta}^g_{iq}(H)} - \frac{\tilde{\theta}^g_{ji}(H)}{\sum_{q=1}^{n} \tilde{\theta}^g_{jq}(H)} \right) \cdot 100 \tag{11}$$

All the metrics discussed above are able to yield insights regarding the mechanisms of market exchange spillovers both from a system-wide and a net pairwise point of view. Furthermore, performing the analyses on rolling windows we are able to study the dynamics of spillover indexes over time.

C. Impulse response functions

To determine the impact of shocks on the stablecoins we start from estimating a Vector AutoRegressive (VAR) model as the one in Equation (3). Also in this case, the VAR model is built on the variables' first differences to make sure that the assumption regarding the stationarity of the analyzed time series is fulfilled.

From the VAR model in Equation 3, we are able to retrieve impulse response functions. In particular, we look at how negative 1-standard deviation shocks in one currency impact the dynamics of the other currencies in the basket and, thereby, the dynamics of the stablecoin. Finally, in order to determine whether shocks in one currency are permanent, we also evaluate cumulative impulse response functions.

IV. Data and empirical findings

A. Data

To test our proposal, we make use of historical data, according to a retrospective analysis. In particular, we use daily foreign exchange rate data over the period 1 January 2002 - 30 November 2019[8]. To build our optimal basket of currencies, we collect data relative to the foreign exchange pairs between the currencies that are included in the IMF's Special Drawings Rights: the US dollar, the Chinese Renmimbi, the Euro, the British pound and the Japanese Yen. According to our research assumption, we will assume that the obtained basket of currencies correspond to a stable coin which can be exchanged and compared with a single currency based stablecoin, for example based on the US dollar. This, in particular, for foreign individuals sending remittances to their home country.

To understand the relative convenience of remittants, to use a basket based coin rather than a dollar based one for example, we have also collected exchange rate data, again over the period 1 January 2002 - 30 November 2019[9], for the most important remittance market currencies (besides China's Renmimbi, already in the basket), namely the Indian Rupee, the Mexican Peso, The Philippines Peso, the Nigerian Naira. Moreover, for what concerns the volatility analysis, we divide the sample into subsets which define the pre-crisis period (2002-2008), crisis period (2009-2011) and post-crisis period (2012-2019).

[8]Data are obtained from *investing.com*

[9]Data are obtained from *investing.com*

Currency	USD	CNY	EUR	GBP	JPY
Optimal Weights	0.21	0.14	0.21	0.21	0.23
IMF SDR Weights	0.42	0.11	0.31	0.08	0.08

Table I
Weights of the currency in the chose basket, according to our methodology (Optimal) and the IMF Special Drawing Rights (IMF SDR)

Finally, for the sake of comparison with a widely known basket-based currency such as the IMF SDR, we also collect data relative to the foreign exchange pair of the dollar with the IMF Special Drawing Rights.

Daily foreign exchange data are then used to compute the reduced normalized values, as illustrated in Section III. In this way, it is possible to analyze the dynamics of exchange rates without imposing any choice of base currency.

B. Optimal basket and stability analysis

First of all, we compute the RNVALs as described in Section III.

The resulting weights are contained, together with those of the IMF SDR, in Table I.

From Table I note that our method yields weights which are quite similar among each other, with the exception of the Chinese Renmimbi. The weights are quite different from the weights of the IMF SDR, which are highly concentrated on the USD dollar. The low weight of the Chinese Renmimbi in our basket can be explained by the fact that the Chinese currency roughly replicates the behaviour of USD. Indeed, in the considered period, it is pegged to it for most of the sample period, although with higher volatility. This makes our method to select a higher quantity of USD rather than CNY, being the former less volatile than the latter. Note also that our method selects a slightly higher portion of JPY compared to the other currencies. This is arguably due to the fact that JPY is the one which is least synchronized with the other currencies in the basket and, therefore, exerts an important diversification effect by reducing the overall volatility of the basket.

To better interpret the results, Figure 1 represents the time series of the Reduced Normalised Values of all considered currencies in the basket, along with our basket based stable coin, in the considered period.

Figure 1 shows the evolution of the RNVALs of the currencies composing the basket during the whole sample period.

From Figure 1 note that, after a first period of small turbulences, the time series start to diverge roughly from the beginning of 2006 onwards. From that point in time onwards, two clusters seem to emerge from the graph: the first one includes USD and CNY, while the second one pertains EUR, GBP and JPY. This is arguably due to the fact that, for many years, the CNY value was pegged to the dollar and, therefore, its dynamics over time shows quite similar patterns to that of the USD. Note that, as expected by construction, the Reduced Normalised Value of the basket based stable coin lies in the middle, ”mediating” between the

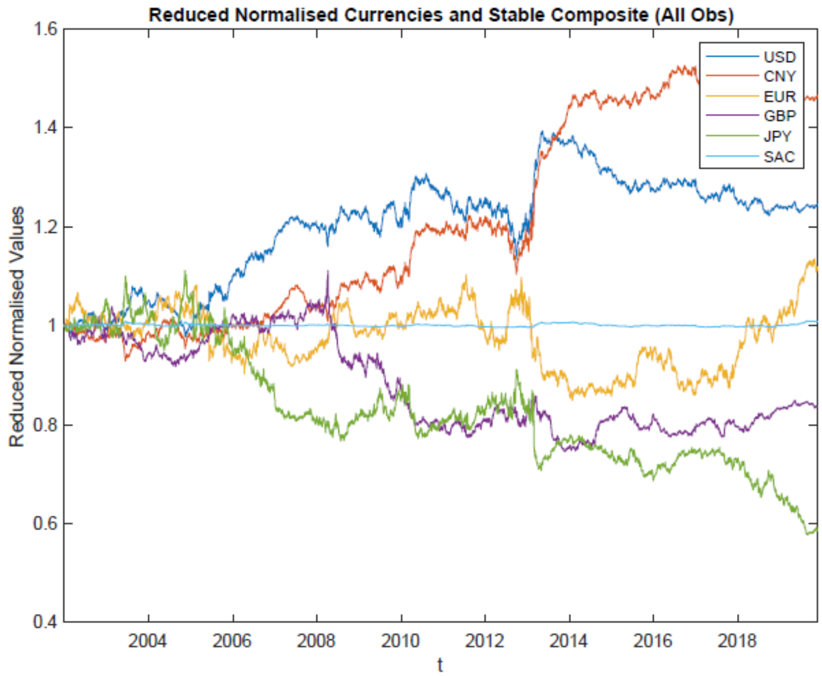

Figure 1
Time evolution of the Reduced Normalised VALue of the basket currencies (USD, CNY, EUR,GBP, JPY), and of the basket based stable coin (SAC)

different currencies, and compensating single deviations with diversification benefits.

For the sake of analyzing the world's emerging market currencies with the highest portions of remittances, we recompute the RNVALs including them. The corresponding graphical representation is contained in Figure 2. In the figure we have included, besides our basket based stable coin, another one that employs the same weights as the Special Drawing Rights.

Figure 2 is consistent with Figure 1, with USD and CNY showing similar patterns over time. All the other currencies seems to belong to another cluster, in the sense that they do not follow an upward trend as the previous ones, but rather fluctuate below the value of 1, with different patterns. The only exception is the Indian rupee (INR), whose value grows over time, although not with the same magnitude as USD and CNY do. Note that both basket based stable coins lie in the middle, similarly as in Figure 1, although their Reduced Normalised value fluctuates. This because the baskets are built using only five currencies, but are normalised with respect to all nine included in Figure 2.

To understand more precisely which stable coin is more stable (Libra: single currency based, or Librae: basket based), Table II presents their volatilities, measured by. their standard deviations, in the considered time period. The table presents also the correlations between the currencies, which help the interpretation of the results.

Table II shows, as far as correlations are concerned, that USD and CNY exhibit relatively strong negative correlations with all others currencies in the basket, but positive between themselves, consistently with what

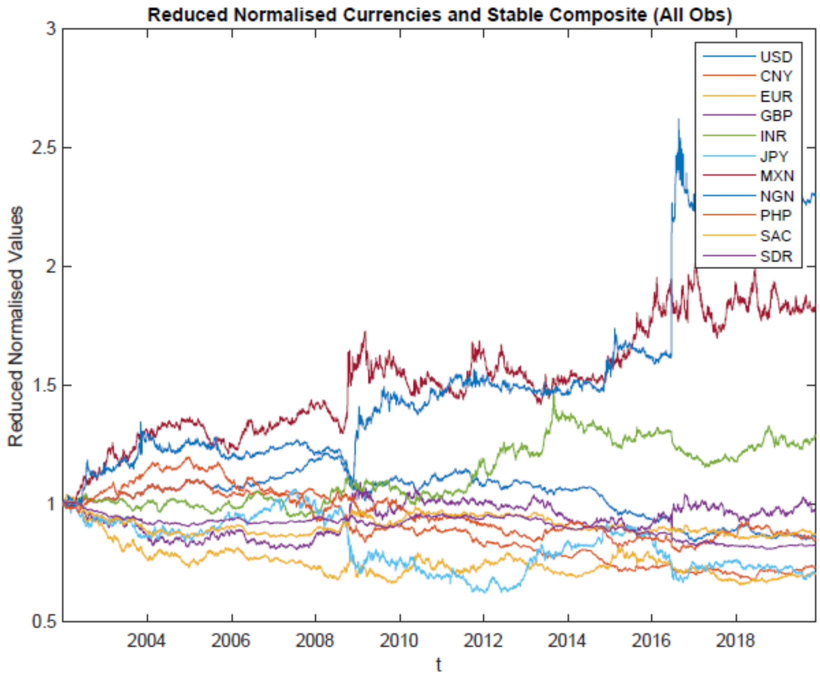

Figure 2
Time evolution of the Reduced Normalised VALue of the basket currencies (USD, CNY, EUR,GBP, JPY), of the considered emerging market currencies (INR, MXN, NGN, PHP) and of the basket based stable coins (SAC, SDR)

	USD	CNY	EUR	GBP	JPY	SAC
USD	1	0.79	-0.48	-0.76	-0.86	0.023
CNY	0.78	1	-0.45	-0.83	-0.86	0.012
EUR	-0.48	-0.45	1	0.2	0.24	0.04
GBP	-0.76	-0.83	0.22	1	0.66	0.027
JPY	-0.86	-0.86	0.24	0.66	1	0.02
SAC	0.02	0.01	0.039	0.027	0.02	1
σ	0.11	0.2	0.06	0.09	0.12	0.003

Table II
Volatility and Correlations between the RNVALs of the basket currencies, and the optimal basket based stable coin.

	USD	CNY	EUR	GBP	INR	JPY	MXN	NGN	PHP	SAC	SDR
σ_{all}	0.09	0.14	0.07	0.06	0.13	0.11	0.22	0.41	0.10	0.04	0.05
σ_{pre}	0.05	0.02	0.04	0.03	0.04	0.07	0.11	0.35	0.03	0.01	0.03
σ_{cri}	0.02	0.04	0.03	0.03	0.12	0.07	0.05	0.04	0.03	0.02	0.02
σ_{post}	0.05	0.06	0.08	0.07	0.04	0.08	0.15	0.09	0.07	0.03	0.02

Table III
Volatility of the RNVALs of the basket currencies, of the emerging market currencies, and of the two basket based stable coins, over the whole period (all), the pre-crisis period (pre), the crisis period (cri) and the post-crisis period (post).

observed in Figure 1. Moreover, one can clearly notice that the EUR acts as a good diversifier, as its pairwise correlations are quite low if compared to those between other currencies. More importantly, from the correlation matrix we can deduce that the stablecoin shows correlations with the other currencies whose values are very close to zero. Low correlations with the other currencies is a clear sign of the goodness of our stablecoin in being isolated with respect to the fiat currencies' dynamics and, therefore, arguably stable. In terms of volatility, the standard deviations show that the most volatile currency is CNY, followed by JPY and USD. Our stablecoin exhibits a standard deviation magnitude which is much lower than those of the other currencies and about ten times lower than that of the least volatile one, namely EUR. This is a clear sign of stability of the proposed stablecoin, as opposed to an hypothetical stablecoin pegged to one single currency.

To determine whether a basket-based stable coin would be a more valuable and more stable alternative than a stablecoin pegged to a single currency, especially for remittances, we can, in analogy with 2, compare the volatility of our stablecoin with that of a SDR based basket, and with the currencies of the most important emerging markets in terms of remittances. Table III contains the comparison, over the whole period and also in three distinct periods, corresponding to the pre-crisis period, the crisis period and the post-crisis period.

From Table III first row, the stablecoin exhibits lower values of volatility, when compared to the other traditional fiat currencies. The other rows in the Table that is always the case, with the exception of the crisis period, in which the USD has a comparable volatility. Indeed, the sovereign crisis in the Euro zone played a role in the devaluation of the currencies pertaining the Euro area. This causes a relatively higher instability of the SAC when compared to the USD. As a consequence, the SDR, whose value is mostly determined by the USD, shows a low volatility as well. For the same reason, and for the persistence of the effects caused by the crisis, the low volatility of the SDR is confirmed during the post-crisis period. Overall, the proposed stablecoin lower volatilities if compared to the single currencies in the basket and to the single emerging market currencies. This can be read as a strength of our stablecoin, as it could function as a better medium of exchange than a country's single currency, in particular as far as remittances are concerned. Note also that the SDR is a valid alternative to our stable coin, possibly easier to implement, from a political consensus viewpoint.

	USD	CNY	EUR	GBP	JPY	FROM
USD	44.94	35.33	13.02	6.67	0.04	11.01
CNY	34.49	49.40	10.76	5.34	0.00	10.12
EUR	15.81	15.22	62.29	6.48	0.19	7.54
GBP	11.4	10.21	6.28	69.58	2.53	6.08
JPY	0.41	0.14	0.01	3.94	95.51	0.90
TO	12.42	12.18	6.01	4.49	0.55	35.66

Table IV
Spillover table

C. Spillover analysis

We now consider spillovers between exchanges, to evaluate the price change connectedness of the currencies that compose the basket, and to understad which is the relative importance of each of the currencies in transmitting shocks. In this way, we are also able to determine which currencies potentially cause strong (or weak) price changes in our proposed stablecoin value.

As far as specifications are concerned, VAR models are built on price changes in reduced normalized values (RNVALs). We use a VAR lag determined by a Bayes-Schwarz information criterion (BIC) that penalizes overparametrization compared to other widely employed information criteria. The optimal number of lag determined by the BIC is 1. We use a $H = 100$ step-ahead forecast horizons for forward iteration of the system. Additionally, dynamic spillovers use a rolling estimation window of length 100 observations.

Firstly, we provide an analysis of unconditional price change spillovers, that are spillovers evaluated on the whole sample period. The results are shown in Table IV.

From Table IV note that there are two currencies which are highly interconnected with the others, meaning USD and CNY, whereas EUR, GBP and in particular JPY are more isolated in terms of return connectedness. Furthermore, the scene appears to be dominated by USD and CNY, whose contributions in terms of price change spillovers towards other currencies are much higher than those of the remaining currencies in the basket.

The analysis of dynamic spillovers is able to clarify the results obtained in the unconditional spillover analysis by means of observing the evolution of spillovers over time. Figure 3 shows the results.

Figure 3 depicts the overall dynamic spillover plotted over the sample period. The overall spillover within the basket ranges from a minimum of 17.87% to a maximum of 80.00%. It seems that the overall spillover follows a generally decreasing trend, as it starts from 54.51% at the beginning of the sample period, while it diminishes to 34.43% at the end of the studied time frame.

Dynamic directional spillovers can shed light on which of the currencies transmit price change spillovers to others and which of them receive price change spillovers from others. We plot from, to, net and pairwise spillovers in Figures 4, 5 and 6, respectively.

From the joint analysis of Figures 4, 5, 6 and **??** we can highlight that that USD is the most influential

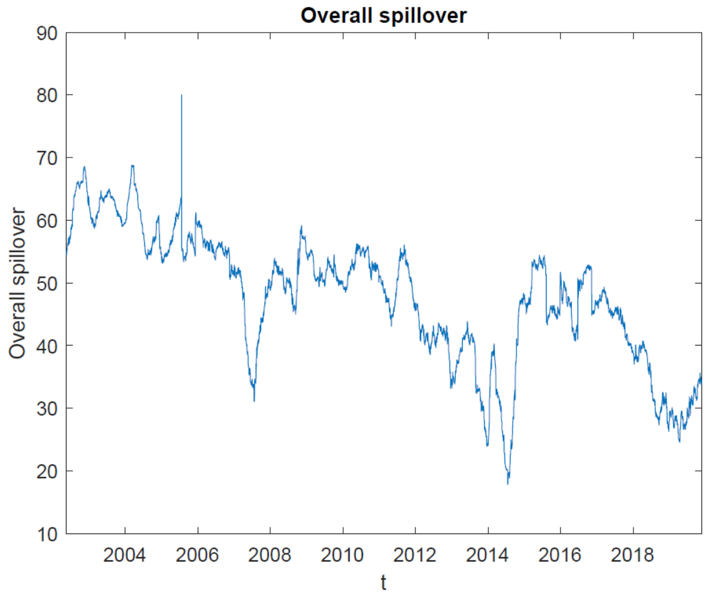

Figure 3
Overall spillovers

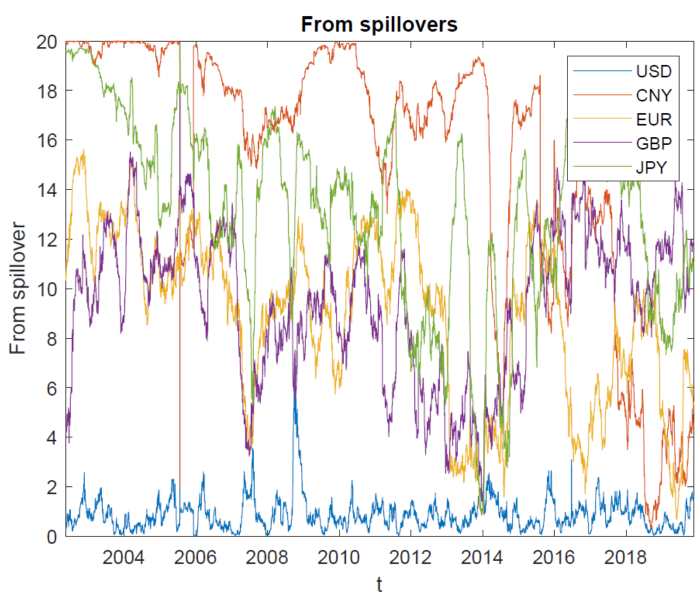

Figure 4
From spillovers

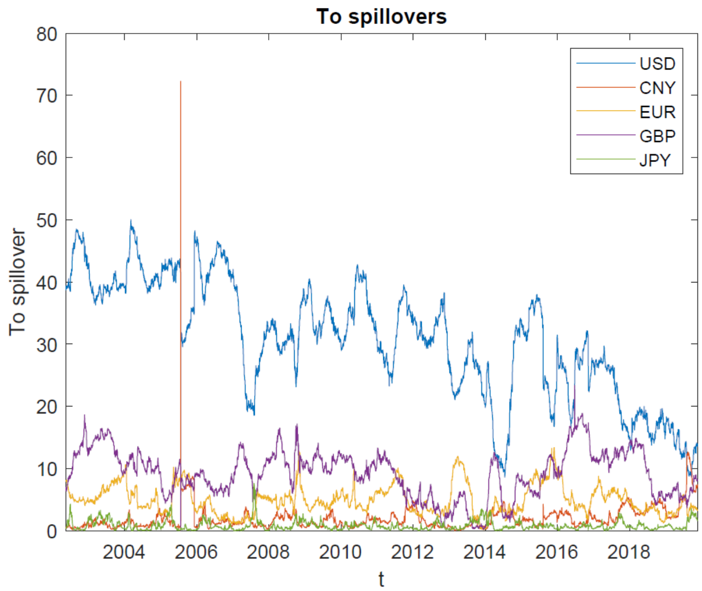

Figure 5
To spillovers

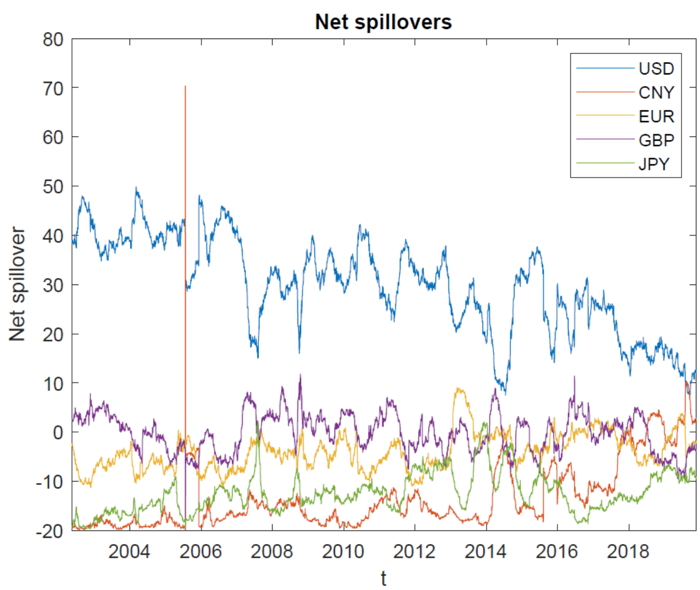

Figure 6
Net spillovers

currencies in terms of return spillovers. Indeed, the magnitude of spillovers received from others is weak compared to that transmitted to others. Moreover, the net spillover dynamics summarizes the dominant position of the USD, being it always positive and taking relatively high values over the sample period. However, the magnitude of spillovers transmitted by USD follows a negative trend over time, meaning the currency is gradually losing its potentiality to contribute to the evolution of the others, perhaps due to the affirmation of emerging economies in the latter period, especially after the 2009 crisis. Despite that, the latter considerations are in line with the full sample results obtained above, which point to the dominance of USD as a spillover transmitting currency.

Differently from what emerged in the full sample analysis, instead, the dynamic analysis shows that CNY is not such a leading currency in transmitting price change shocks. Indeed, the full sample result is arguably driven by a noticeable spike which occurred on 21 July 2005. Indeed, during that day the Chinese Central Bank officially announced the abandonment of the eleven-year-old peg to the dollar and pegged the CNY to a basket of currencies whose composition was not disclosed. This caused a prompt revaluation to CNY 8.11 per USD, as well as to 10.07 CNY per euro. However, the peg to the dollar was reinstituted as the financial crisis strengthened in July 2008. These results indicate that CNY does not particularly contribute to the price change evolution of the other currencies in the basket, although it can exert shocks through sudden policy decisions.

D. Impulse Response to currency shocks

We now apply the impulse response function tools to analyze the impact of currency shocks on the basket. We plot the impulse response functions for some currencies in Figure 7. Specifically, leveraging the results from the previous subsection, we consider USD as shock source, being the most important transmittant of spillovers. In addition, we consider EUR being the second most important residence of foreign remittants. Besides the two single currencies, we consider the to basket based stable coins, the optimal and the SDR one. Figure 7 shows the results of the impulse response analysis.

From Figure 7, we can see the impact of a negative 1-standard deviation shock in the USD on the different currencies. We can clearly notice that the impact of a USD shock is much higher on the dollar itself than on the stablecoin, being the magnitude of the impact lower. This is true also when looking at an IMF SDR versusa stablecoin shock. Moreover, the impact of the latter shock has opposite direction with respect to that on the USD. Given the correlation structure among the currencies, the stablecoin is indeed positively affected by a negative one standard deviation shock in the USD. This yields to the conclusion that a basket-based currency is less influenced by currency shocks than single currencies themselves.

With the aim of evaluating the persistence of currency shocks on the stablecoin value, we plot the cumulative impulse response functions for relevant currencies in Figure 8.

Figure 8 shows that a shock in the USD translates into a permanent effect on the USD itself, on the stablecoin and on the SDR as well. However, the magnitude of the permanent impact is way lower on the stablecoin than in the other two currencies. The same is true when comparing the permanent effects of

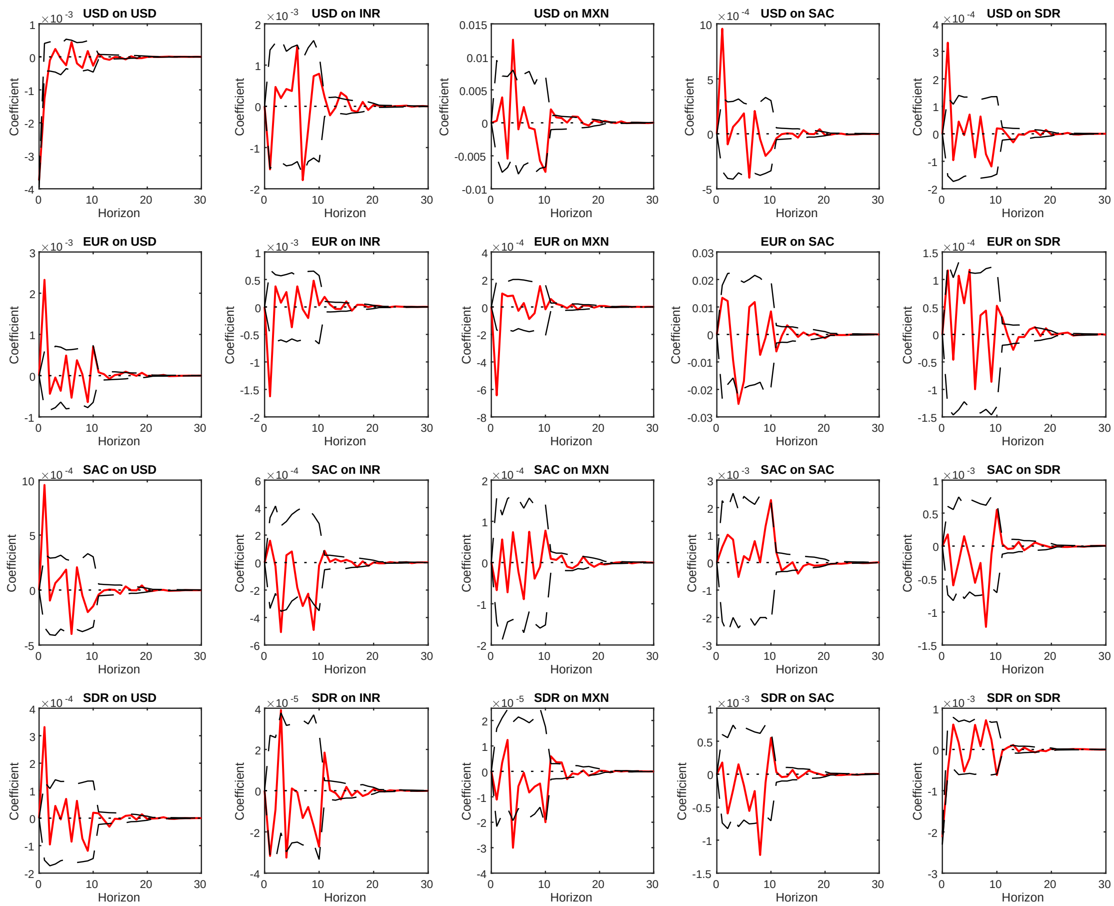

Figure 7
Impulse response functions

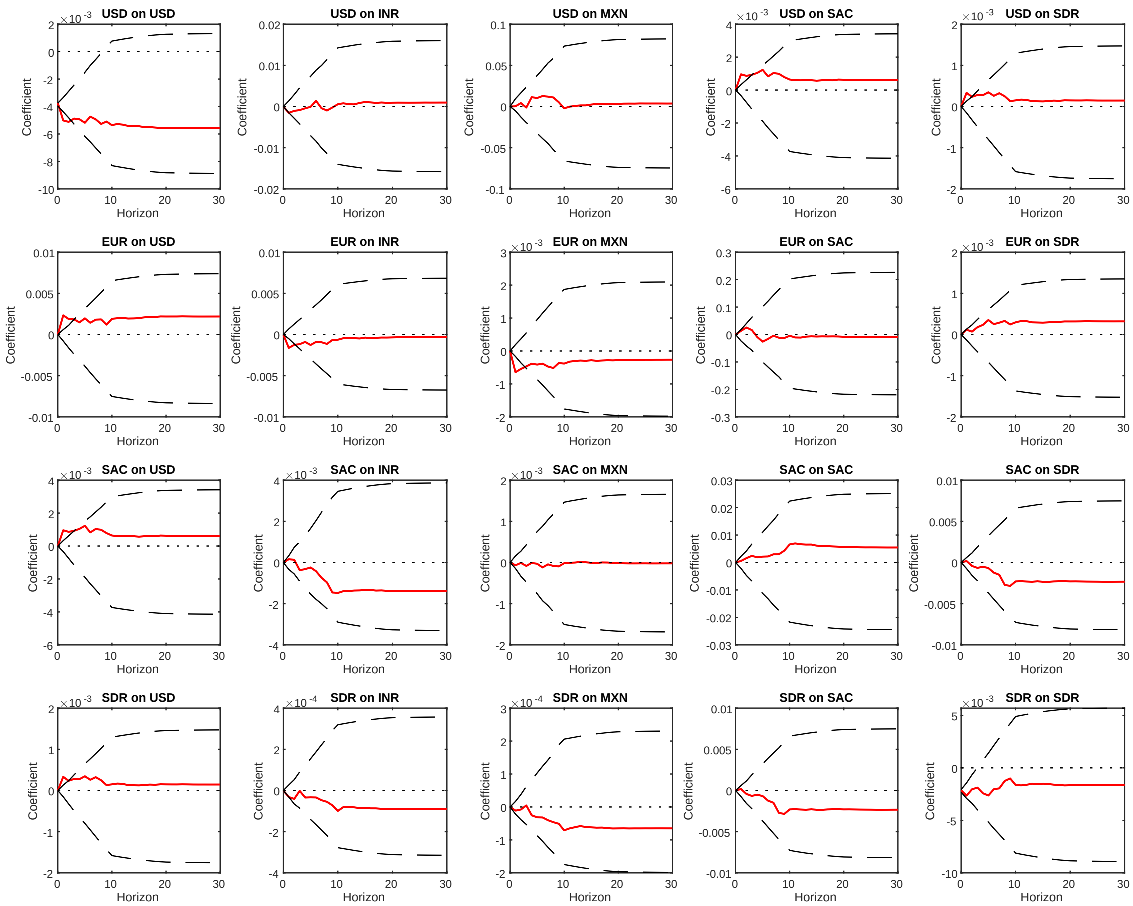

Figure 8
Cumulative impulse response functions

shocks in the EUR on itself, the stablecoin and the SDR. This suggests that single currencies are more prone to be permanently impacted from shocks than basket-based ones, especially if compared to the proposed stablecoin.

V. Conclusion

In the paper we present a methodology to build a basket based stable coin whose weights can maximise stability over a long time period. The weights have been calculated, retrospectively, for the period that follows 2002, and show a distribution more even than the IMF Special Drawing Rights weights.

The proposed stable coin (Librae) appears to be less volatile than single currencies and, therefore, with respect to single currency stable coins (Libra). It can thus constitute a valuable proposal especially for workers who live abroad and make remittances to their own country, a market segment with a high potential of being attracted by payments in stablecoins.

We have also proposed a variance decomposition technique, and an impulse response function analysis, both based on a VAR model, aimed at showing which currencies mostly impact the Foreign Exchange market and whether a single currency or a basket based stablecoin is more resilient to currency shocks. Our results show that the dollar is the currency which mostly impact the market, and that a basket based coin is better than a dollar based one, from a stability and value maintenance viewpoint.

With a basket based stablecoin it is possible to offset the risk of currencies shocks. This is of relevance for different policy purposes and, in particular, for emerging markets and countries having high remittances. Indeed, by holding stablecoins rather than single currencies the risks associated to currency shocks are mitigated and stablecoins holder can count on a currency whose value is less volatile than traditional fiat currencies and, thereby, more reliable. The latter fact has also positive consequences on cross-border payments side, provided that the stability of the stablecoin mitigates the foreign exchange risk, thus contributing to the fact that buyers and sellers give or receive an amount of money whose value is less sensitive to variations over time.

Future research may consider basket that dynamically evolve over time (”AI baskets”), although these are bound to be more difficult to achieve consensus. Furthermore, currency volumes in circulation may be taken to account, along with the technical characteristics of the coins (for example: cybersecurity, redeemability, reliability), from a different, more theoretical, viewpoint.

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References

Acosta PA, Baerg NR, Mandelman FS. 2009a. Financial development, remittances, and real exchange rate appreciation. *Economic Review* **94**.

Acosta PA, Lartey EK, Mandelman FS. 2009b. Remittances and the dutch disease. *Journal of international economics* **79**: 102–116.

Bank for International Settlements. 1996. Implications for central banks of the development of electronic money.

BARAJAS A, CHAMI R, HAKURA D, MONTIEL P, Tressel T. 2011. Workers' remittances and the equilibrium real exchange rate: Theory and evidence [with comment]. *Economía* **11**: 45–99. ISSN 15297470.
URL `http://www.jstor.org/stable/41343450`

Bullmann D, Klemm J, Pinna A, et al. 2019. In search for stability in crypto-assets: are stablecoins the solution? Technical report, European Central Bank.

Carney M. 2019. The growing challenges for monetary policy in the current international monetary and financial system. In *Remarks at the Jackson Hole Symposium*.

Cooper RN. 1984. A monetary system for the future. *Foreign Aff.* **63**: 166.

Diebold FX, Yilmaz K. 2012. Better to give than to receive: Predictive directional measurement of volatility spillovers. *International Journal of Forecasting* **28**: 57–66.

Diebold FX, Yılmaz K. 2014. On the network topology of variance decompositions: Measuring the connectedness of financial firms. *Journal of Econometrics* **182**: 119–134.

European Central Bank. 1998. Report on electronic money.

Financial Stability Board. 2019. Regulatory issues of stablecoins.

Gopinath G, Boz E, Casas C, Díez FJ, Gourinchas PO, Plagborg-Møller M. 2016. Dominant currency paradigm. Working Paper 22943, National Bureau of Economic Research.
URL `http://www.nber.org/papers/w22943`

Hovanov NV, Kolari JW, Sokolov MV. 2004. Computing currency invariant indices with an application to minimum variance currency baskets. *Journal of Economic Dynamics and Control* **28**: 1481–1504.

Humpage O. 2009. Will special drawing rights supplant the dollar? `https://voxeu.org/article/sdr-vs-what-it-takes-be-international-reserve-currency`.

Levene T. 2006. ‘Cashless society’ card that flopped. *The Guardian* .
URL https://www.theguardian.com/money/2006/apr/15/moneysupplement1

McKinnon RI, et al. 1984. An international standard for monetary stabilization .

Ocampo JA. 2019. Is it time for a ’true global currency’? https://www.weforum.org/agenda/2019/04/is-it-time-for-a-true-global-currency.

Rogoff K. 2001. Why not a global currency? *American Economic Review* **91**: 243–247.

Williamson J. 1993. Exchange rate management. *The Economic Journal* **103**: 188–197.