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Beyond the dollar: A global perspective on exchange rate dynamics via currency factors

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A B S T R A C T

This paper investigates the dynamics of currency exchange rates from a global perspective, by expanding on the concept of currency factors. Through the analysis of G10 currencies, we disclose the interconnections and patterns driving exchange rates, shedding light on the central role of the euro and Swiss franc in shock propagation. Furthermore, we observe that pound and yen factors have acted as net absorbers of spillovers from other currencies. Our findings suggest that currency factors provide valuable insights for international diversification, risk sharing strategies, and real-time indicators of foreign exchange market uncertainty.

1. Introduction

Association with economic fundamentals (Meese and Rogoff, 1983; Rossi, 2013). This study adds to an emerging body of literature recognizing that an improved understanding of exchange rates can be attained when currencies are assessed in relation to each other, rather than independently. We delve into this proposition by scrutinizing the interconnections among currency factors. This places our research within the literary sphere that encompasses predictability studies of currency returns in the form of the dollar, momentum, carry and value strategies (Aloosh and Bekaert, 2022; Colacito et al., 2020; Lustig and Verdelhan, 2019; Verdelhan, 2018).

Current literature establishes a link between fluctuations in exchange rates and country-specific economic shocks. Exchange rates, by their very nature, serve as a bridge between two currencies and any observed variation may emanate from diverse sources. Let r_{ij} be identified as the fluctuation in the bilateral exchange rate between currencies i and j. Shocks can originate from i's economy, j's economy, or both, influencing exchange rate variation. To disentangle individual effects originating in each currency, particularly the USD, Verdelhan (2018) revived the notion of the dollar factor as a currency basket, measured as the average appreciation of USD against a set of currencies. Verdelhan's (2018) approach, however, is numeraire dependent (on USD), limiting perspective for a global investor. In addition, the interconnectedness of bilateral exchange rates can also influence third-party currencies due to their linear dependence. Take, for instance, an appreciation in the GBPUSD, which inevitably triggers adjustments in GBPEUR and/or EURUSD. Consider an investor who wishes to liquidate USD in favor of GBP. This transaction can be accomplished directly through GBPUSD, or indirectly by first converting to EUR via EURUSD and subsequently to GBP through GBPEUR. Assuming the difference in transaction costs for performing the operation either way is non-significant, the investor would be indifferent to the chosen method in the absence

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of triangular arbitrage and liquidity constraints.

We aim to build upon the dollar factor by expanding it to a general framework that factors all currencies under examination, as proposed recently by �Aloosh and Bekaert (2022, henceforth A-B). Our work bears a resemblance to A-B approach yet diverges on three significant counts. First, we highlight the interrelationships between currency factors, emphasizing the inherent linear dependence structure. In contrast, A-B use the first component of the 45 pairs formed by the G10 currencies as a measure of global (common) variation. However, it can be shown that their PCA results are dependent upon the choice in composition of each pair (i.e., EURUSD or USDEUR), which by itself results from the order given to each currency in the currency matrix. Second, our empirical study offers a more granular view (20x) by shifting from monthly to daily observations – a timeframe in which models have faced challenges and displayed limited predictability (Rogoff and Stavrakeva, 2008; Rossi, 2013). Third, we are interested in measuring return spillovers, enabling us to examine how currencies comove and how shocks propagate through the foreign exchange price mechanism.

2. Data and methodology

2.1. Currency factors

First, we determine daily returns for the 45 bilateral exchange rates among G10 currencies as detailed in the online appendix. Currently, G10 currencies are estimated to account for about 86% of exchange rate turnover, encompassing spot, future and swap transactions (BIS, 2022). Original data, spanning January 1975 to September 2020, is sourced from the Bank of England. We define a currency factor (CF) for each currency *i* as:

$$CF_{t,\ i} = \left(\sum_{j=1}^{n-1} r_{t,i,j} \right) \Big/ (n-1) \tag{1}$$

where $r_{i,j}$ refers to the daily logarithm appreciation of currency *i* relative to currency *j*. Please note that our currency factor comprises an equally weighted basket of currency *i* appreciation against the remaining (*n—1)* currencies.

2.2. Spillovers between currency factors

Our principal aim is to examine how returns spillover between currency factors over a short predictive time horizon. Our framework is anchored in a 10-variable VAR(p), where $y_t = \sum_{k=1}^{p} \Theta_k y_{t-k} + \varepsilon_t$ is a vector comprising the 10 currency factors assuming independently and identically distributed disturbances over time $\varepsilon_t \sim (0, \Sigma)$. The moving average representation is $y_t = \sum_{k=0}^{\infty} A_k \varepsilon_{t-1}$ where the 10 × 10 coefficient matrices conform to the recursion $A_k = \Theta_1 A_{k-1} + 2A_{k-2} + \ldots + \Theta_p A_{k-p}$, with A_0 being a 10 × 10 identity matrix and A_k=0 for k <0. We employ the generalized (order-invariant) structure of Pesaran and Shin (1998) to create a generalized variance decomposition matrix $D^{gH} = [d_{ij}^{gH}]$, where d_{ij}^{gH} is the *H*-step-ahead forecast error variance decompositions. Our spillover measures adhere to the connectedness methodology introduced by Diebold and Yilmaz (2014, 2012) and consider that the main diagonal elements of D^{gH}encapsulate the self-contributions of shocks to variable *i* to its own forecast error variance, while the off-diagonal elements represent cross-currency returns connectedness, defined as the contributions of other currencies *j* to the forecast error variance of currency *i.* Subsequently, we normalize each entry of the variance decomposition matrix by the row sum to obtain the pairwise directional connectedness measure from *j* to *i* ($\widetilde{d}_{ij}^{g}$ – further details in the online appendix). From this point, we define total directional spillovers from others to *i* ($S_{i\leftarrow\bullet}^{H}$) and to others from *j* ($S_{\bullet\leftarrow j}^{H}$), as well as net spillovers (S_i^H), as:

$$S_{i\leftarrow\bullet}^{H} = \sum_{j=1,\ j\neq i}^{10} \widetilde{d}_{ij}^{g} \tag{2}$$

Table. 1
Correlations between currency factors.

	CF_{AUD}	CF_{CAD}	CF_{CHF}	CF_{EUR}	CF_{GBP}	CF_{JPY}	CF_{NOK}	CF_{NZD}	CF_{SEK}	CF_{USD}
CF_{AUD}	–									
CF_{CAD}	21%	–								
CF_{CHF}	-48%	-44%	–							
CF_{EUR}	-47%	-43%	65%	–						
CF_{GBP}	-23%	-17%	6%	10%	–					
CF_{JPY}	-21%	-17%	9%	-7%	-12%	–				
CF_{NOK}	-28%	-26%	21%	39%	0%	-24%	–			
CF_{NZD}	47%	10%	-45%	-45%	-21%	-21%	-29%	–		
CF_{SEK}	-27%	-25%	20%	40%	-2%	-24%	42%	-31%	–	
CF_{USD}	5%	47%	-36%	-38%	-10%	9%	-37%	0%	-31%	–

Notes: This table illustrates daily Spearman correlations between the G10 currency factors, using a sample spanning from 02-01-1975 to 09-09-2020 (11,553 observations in total).

$$S^H_{\bullet\leftarrow j} = \sum_{i=1, i\neq j}^{10} \tilde{d}^g_{ij} \tag{3}$$

$$S^H_i = S^H_{\bullet\leftarrow i} - S^H_{i\leftarrow\bullet} \tag{4}$$

3. Results and discussion

Our analysis begins with an exploration of the correlation among currency factors and their explanatory power on bilateral exchange rate variance. Table 1 presents the intensity of monotonic relationships between currencies using Spearman's rank-order correlation coefficient. Two distinct patterns emerge: the first shows a solid positive co-movement among Continental European currencies (CHF, EUR, NOK, SEK) as well as American currencies (CAD, USD). This pattern resonates with the A-B findings and support the notion of a geographical factor influencing currency fluctuations, driven by European and American currency blocks. The second pattern might be attributed to international flows and their pricing impact on foreign exchange markets – euro and Swiss franc appreciations (depreciations) are closely linked with dollar currencies depreciations (appreciations). The robustness checks discussed in the online appendix confirm these relationships for different period sub-samples, times of the year, and alternate correlation measures.

We examine how uniformly currency factors affect bilateral exchange rates by individually regressing each exchange rate on every currency factor. By extracting and comparing the R^2 coefficients of these regressions, we can discern which currency factor (*i* or *j*) has the most substantial explanatory power over r_{ij} and r_{ji} variance, as well as comprehend how the latter connects with the other *k* currencies ($k \neq i,j$). Unsurprisingly, we find that variances in bilateral exchange rates are primarily correlated with the variances of their respective currency factors. However, we disclose novel stylized facts relevant from a risk-sharing and hedging standpoint. Firstly, Pacific currency factors (NZD, JPY, AUD) dominate their respective exchange rates, accounting for over two-thirds of the non-normalized variance observed in bilateral exchange rates linked to these 3 currencies (Tables A.5 and A.6). Secondly, most European exchange rates (EUR, NOK, SEK, GBP) are influenced by shocks originating in the other part of the bilateral rate; this is notably evident in the euro exchange rates, as merely 37% of their average fluctuation is tied to the euro factor. Finally, the pound sterling factor appears relatively isolated from the dynamics of other currency factors – barely 1% of its average fluctuation is associated with shocks originating elsewhere, *i.e.*, in non-GBP exchange rates.

Table 2 introduces the spillovers across G10 currency factors, contemplating a generalized VAR of order 4 and a predictive horizon (H) of 10 days. Directional spillovers are exhibited in the upper-left 10×10 submatrix. The column labelled "From other CF" quantifies the proportion of shocks received from other CF in the total variance of the forecast error of each CF. The lower panel displays the sum of spillover contributions to other CF, excluding (above row) and including (center row) the own share of the forecast error variance. Given that each CF's contribution to others' forecast error variance is not restricted to adding up to 100%, entries in the above row can exceed it. As expected, "own" variance accounts for most of the total variation observed in currency factors. However, distinct from other currencies, EUR and CHF emerge as key channels absorbing and diffusing shocks across the G10 network, with both inward and outward spillovers surpassing own effects. From a net perspective (S^H_i), on average, EUR serves as a shock amplifier, with the difference between outward and inward spillovers amounting to 15 p.p. Conversely, our findings reinforce the perception of the GBP as a currency relatively segregated from the G10 network, with less than 10% of its variation impacting other currencies and below 15% of its variation tied to shocks originating elsewhere.

As our sample covers a span of over 45 years, we examine the degree of spillover fluctuation over time using rolling estimation methods. By sampling a dynamic version of Eq. (4) over 200-day rolling windows, we obtain net spillover indices for each CF and plot them in Fig. 1. A visual inspection corroborates the viewpoint of EUR and CHF primarily acting as net diffusers of shocks, while GBP

Table. 2
Spillovers across currency factors.

	CF_{AUD}	CF_{CAD}	CF_{CHF}	CF_{EUR}	CF_{GBP}	CF_{JPY}	CF_{NOK}	CF_{NZD}	CF_{SEK}	CF_{USD}	*From* other CF ($S^H_{i\leftarrow\bullet}$)
CF_{AUD}	53.0	1.2	11.0	11.8	2.7	5.2	3.1	8.7	3.0	0.3	47.0
CF_{CAD}	1.2	55.4	11.1	11.0	1.5	2.2	3.3	0.1	2.9	11.4	44.6
CF_{CHF}	10.2	9.7	49.0	16.0	0.1	0.8	0.8	8.1	0.4	5.0	51.0
CF_{EUR}	9.6	8.5	14.2	43.3	0.6	0.1	4.7	8.3	4.6	5.9	56.7
CF_{GBP}	4.3	2.3	0.2	1.2	85.1	1.7	0.1	3.9	0.2	1.1	14.9
CF_{JPY}	6.9	2.8	1.1	0.2	1.5	70.9	4.8	5.2	4.9	1.6	29.1
CF_{NOK}	3.5	3.5	0.9	6.5	0.1	4.1	60.0	3.7	8.4	9.2	40.0
CF_{NZD}	9.2	0.1	9.2	10.7	2.6	4.1	3.4	55.8	4.0	0.9	44.2
CF_{SEK}	3.5	3.2	0.5	6.6	0.2	4.3	8.7	4.4	62.1	6.6	37.9
CF_{USD}	0.3	11.7	5.8	7.8	0.7	1.3	8.7	0.9	6.0	56.9	43.1
Contribution *to* other CF ($S^H_{\bullet\leftarrow i}$)	48.7	43.1	53.9	71.9	9.8	23.7	37.5	43.3	34.5	42.0	408.4
Contribution including own CF	101.8	98.6	102.9	115.2	95.0	94.6	97.5	99.1	96.5	98.9	$RSI = \frac{408.4}{1000} = 40.8\%$
Net spillovers: *to* – *from* (S^H_i)	1.8	-1.4	2.9	15.2	-5.0	-5.4	-2.5	-0.9	-3.5	-1.1	

Notes: The underlying variance decomposition presented in this table is based upon a daily generalized VAR(4). The *ij*-th entry in upper 10×10 currency factor submatrix gives *ij*-th pairwise spillover, i.e. the estimated contribution to the variance of the 10-day-ahead return forecast error of currency factor *i* coming from innovations to returns of currency factor *j*.

has largely adopted the reverse role (shared with JPY, to a lesser degree). Recent years also reveal heterogeneous patterns among commodity currencies, with negative net spillovers prevailing in CAD and NOK, while positive net spillovers dominate AUD behavior.

Moving to a global dynamic perspective, we construct a rolling return Spillover Index (RSI) by accumulating all variance decomposition “Contribution to others ($S^{H}_{\bullet\leftarrow i}$)” from Table 2, calculated using 200-day rolling windows, and plot the result in Fig. 2. The trends displayed in Fig. 2 lend support to the perspective that economic and financial integration seem to have infused relative tranquility to foreign exchange markets, with RSI marking successive lower-highs and lower-lows as integration processes advanced over the last three decades. Our findings also suggest that significant fluctuations in RSI correlate with major economic and financial events; anecdotal evidence shows that recent major tops in RSI coincide, exactly or within a few days, with key economic event dates such as the sterling pound’s “Black Wednesday” (1992), the US bailout bill (2008), Mr. Draghi’s speech (2013) and the Brexit referendum (2016).

We address potential concerns by conducting several robustness checks, the details of which are provided in the supplementary material available in the online appendix. First, we explore other potential linear and non-linear relationships by repeating the correlation analysis using Pearson and Kendall methods (Tables A.2 and A.3). Despite the study’s reliance on linear models like VAR, we found that the outcomes are largely consistent and extremely highly correlated with the Spearman method. However, we do acknowledge that the complex, potentially non-linear relationships between currencies might not be fully captured by the model used in this study. Secondly, our methodology requires making assumptions such as the lag length (p) of the VAR as well as the predictive horizon H. We address this concern by replicating our analysis using more stringent coefficients ($p = 1, H = 2$; Fig. A.1) and the overall findings remain valid. Lastly, aware of the potential limitations of our generalized VAR-based results, we verified their robustness by performing our analysis using 18 random permutations of Cholesky decomposition. The consistent dynamic behavior of the index observed in Fig. A.2 suggests that our findings are robust to the specific method of decomposition used.

To substantiate our findings’ robustness and reliability, we have further undertaken an alternative analysis by implementing a time-varying parameter vector autoregression (TVP-VAR) framework. This approach allows the variance-covariance matrix to be flexible by applying a Kalman filter estimation with forgetting factors (κ1 = 0.99, κ2 = 0.96; Koop and Korobilis, 2014). Our results using the TVP-VAR method largely corroborate the relative positions between the currency factors observed in our initial analysis (Table A.7). An intriguing exception, however, pertains to the USD currency factor; its role shifts from a relatively minor shock absorber in the original analysis to a diffuser in the TVP-VAR framework. Also the spillover index demonstrates similar tendencies under both the rolling-window VAR and TVP-VAR models, albeit with the TVP-VAR variant demonstrating greater volatility (Figure A.3). Given the daily frequency of our data, the choice between these two approaches may be dictated by the relevant temporal horizon for individual stakeholders.

For practitioners working within the global financial market, this study offers relevant insights for strategic decision-making. Investors can leverage this knowledge in portfolio diversification, especially with the discernments about shock propagators and insulators in the currency network. For corporations and financial institutions with international operations, these findings may serve to design tailored hedging strategies, thus enhancing their capacity to manage exchange rate risks. Moreover, risk managers can incorporate the identified shock propagation dynamics into their scenario models, contributing to the quantification of potential losses during extreme market conditions.

From a policy standpoint, these findings are important. In formulating monetary policy, central banks should be cognizant of the

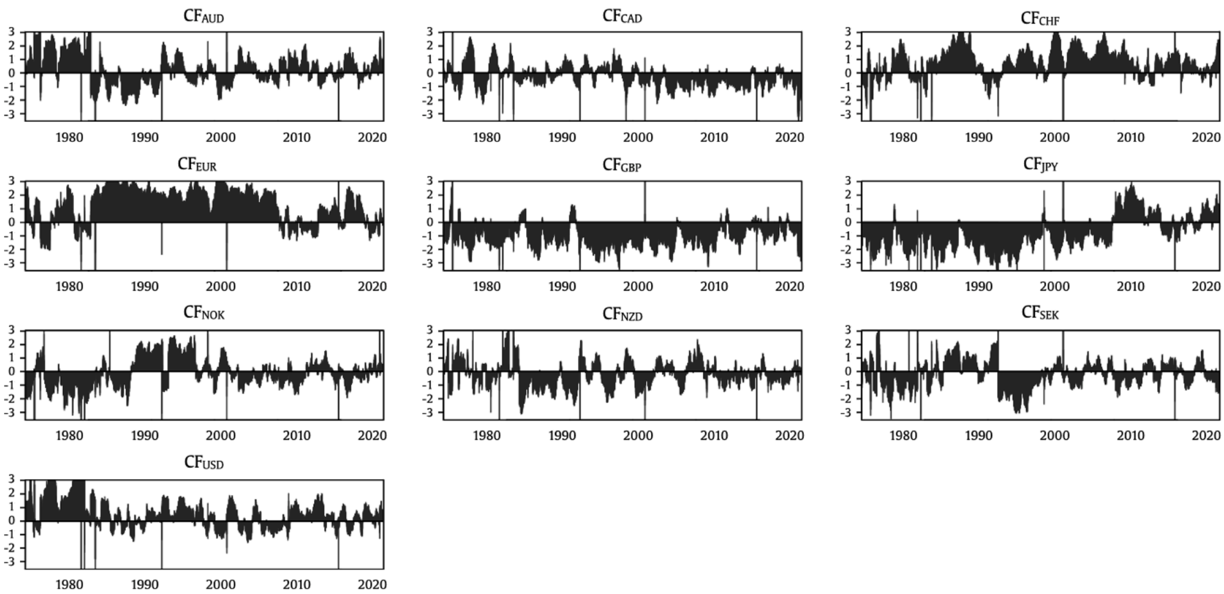

Fig. 1. Dynamic net spillovers of currency factors.
Notes: This figure displays net return spillovers, using 200-day rolling windows and a 10-day predictive horizon.

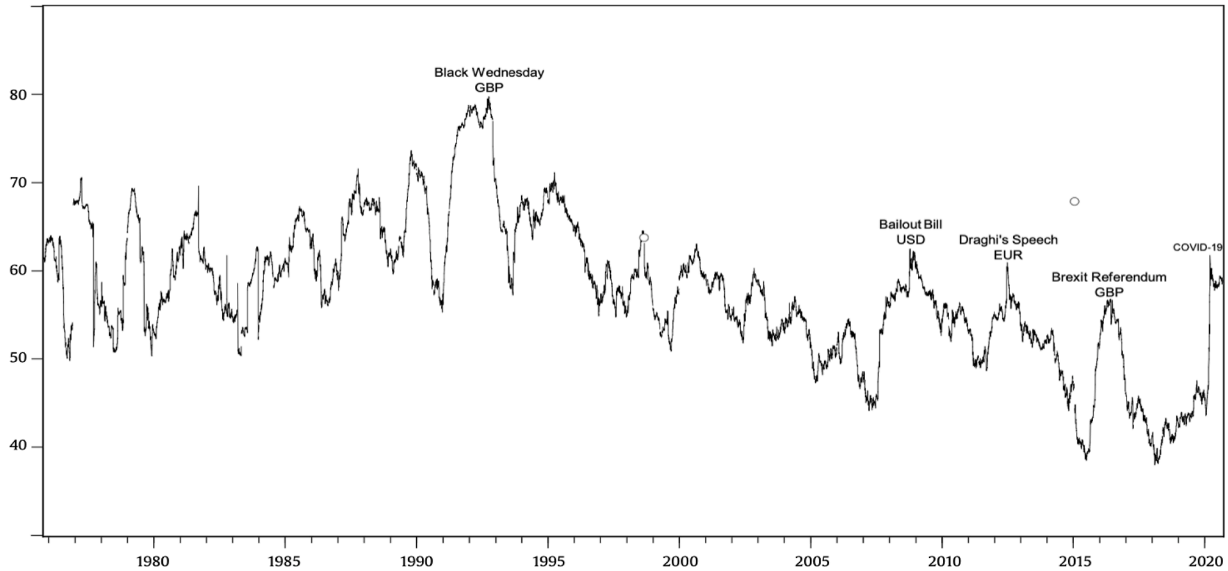

Fig. 2. Rolling spillover index.
Notes: This Figure plots total return spillovers, using 200-day rolling windows and a 10-day predictive horizon.

potential international repercussions of their decisions, especially when their currency is a net diffuser of shocks. Understanding the transmission mechanism and the interconnected nature of currency dynamics can assist in mitigating unwanted spillover effects and enhancing policy efficacy. Furthermore, regulators and policymakers can harness this information to ensure financial stability. By monitoring the degree of currency return spillovers, they can ascertain periods of increased market uncertainty, which often coincide with significant economic and financial events. This could facilitate the timely implementation of measures to curb excessive market volatility, thereby promoting a stable and resilient global financial system.

4. Conclusion

In this study, we propose that currency factors carry informational value by untangling the influence each currency holds on exchange rate dynamics. We uncover driving forces and interrelations governing G10 currencies that bilateral exchange rates fail to expose. First, we corroborate the presence of a geographic factor influencing American, European, and Pacific exchange rates, aligning with recent propositions by Aloosh and Bekaert (2022) and Lustig and Richmond (2020). Second, we unveil two novel stylized facts of importance for international diversification and risk-sharing strategies: (1) The euro and Swiss franc factors are highly correlated and exposed, serving as major channels of shock propagation *from* and *to* other currencies; (2) The pound and, to a lesser extent, the yen factors are the most insulated within the G10 network and have predominantly absorbed spillovers from other currencies. Finally, we show that aggregate currency return spillovers peak in sync with major economic and financial events, possibly acting as a real-time indicator of the degree of uncertainty permeating foreign exchange markets.

A parsimonious currency factor model could present a valuable supplement to the existent array of macro-finance measures and models which are numeraire dependent on the dollar. The informational content it provides, viewed through a global lens, may be appealing to the dynamic hedging industry and research community. Nevertheless, much is still to be thoroughly understood: what influences the behavior of currency factors? How does its predictive ability compare to alternative models? How do currency factors intersect with other financial instruments from a cross-market standpoint? We foresee these questions steering future research in this topic.

Data availability

Data will be made available on request.

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Supplementary materials

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