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Quantitative Portfolio Strategy

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Diversifying Base Currency Risk[1]

- In most global portfolios, currency exposure is managed relative to a single base currency. This exposes investors to shocks in base currency valuation, which can come from country-specific factors such as domestic economic and monetary policy.
- We advocate that investors consider diversifying base currency risk by managing FX exposure relative to a basket of currencies rather than to the single domestic currency of their liabilities. This is similar to diversifying portfolio funding across several currencies.
- We find that diversifying base currency risk can deliver significant risk reduction and transform the carry properties of a portfolio, potentially leading to higher Sharpe ratios.
- We discuss portfolio examples in three different asset classes – money markets, bonds and equities – and provide an analytical explanation of base currency diversification.

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[1] We are grateful to Robert Fuhrman, from Wellington Asset Management, for bringing this topic to our attention

Base Currency and Portfolio Risk

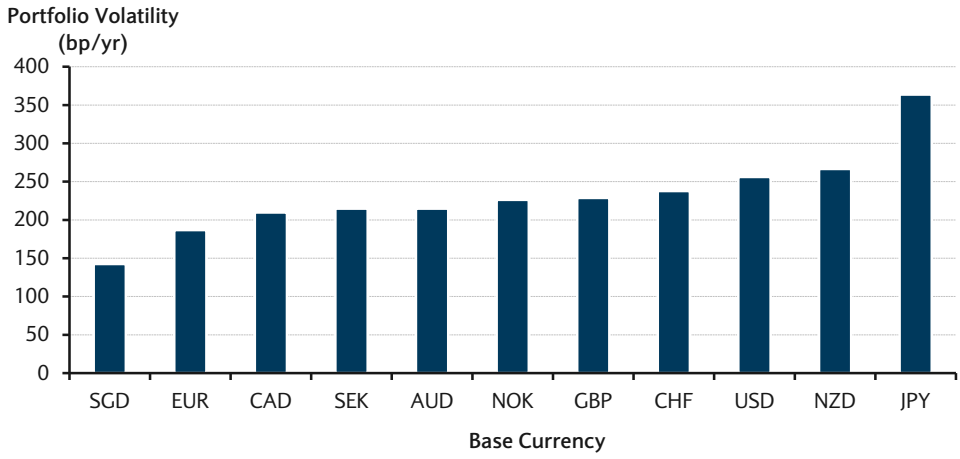
Investors often associate foreign exchange (FX) risk with shocks in *foreign* (as opposed to *domestic*) currencies. A European portfolio manager investing in US assets would typically identify currency risk as USD volatility, while a US manager investing in European assets would describe currency risk as changes in the EUR value. While both managers refer to the same risk embedded in the EURUSD exchange rate, they each tend to attribute it to changes in valuation of the foreign currency rather than the domestic one. Exchange rate volatility, however, can come from both domestic as well as foreign shocks. Measuring them in units of the domestic currency is just a referencing exercise. Therefore, an international portfolio diversified across many markets remains exposed to shocks in the domestic (base) currency. While base currency volatility is often seen as a systematic risk associated with foreign exposures, a significant portion of it may be idiosyncratic. Indeed, the relative valuation of a domestic currency is affected by domestic economic cycles and monetary policies, which are not necessarily globally synchronized.

One possible way to reduce risk is to fully (or partially) hedge foreign currency exposure back to the domestic base currency. Doing this can effectively transform foreign currency deposits into a domestic currency deposit. But exposure to foreign currencies can be an inherent part of the investment process, for example to capture the carry premium. In that case, currency hedging would defeat the purpose of global investing. So, the question is rather how to control the currency risk of an international portfolio while retaining its broad properties.

In Figure 1 we compare volatilities of an equally weighted portfolio of 12 emerging market (EM) deposits[2] reported in different base currencies. Each bar of Figure 1 represents the volatility of the same investment expressed in a given base currency. Historical volatilities shown below vary according to the base currency in which portfolio returns are measured. Figure 1 shows that our example portfolio is more volatile when expressed in JPY than in SGD (364 vs. 143bp/m). Although the investment leg of the portfolio is diversified across various EM currencies, the funding (base) currency is unique, and this concentration affects portfolio risk.

FIGURE 1

Volatility of an equally weighted portfolio of EM deposits expressed in different base currencies (January 2004 to December 2014)



Source: Barclays Research

[2] This example portfolio is equally weighted across 1-month deposits in BRL, CLP, COP, HUF, ILS, INR, KRW, MXN, MYR, PLN, THB, and ZAR. We use deposit rates implied by mid 1-month FX forward points vs. USD and 1-month USD Libor.

Figure 2 presents the correlation matrix of monthly returns for the deposit portfolio reported in different base currencies. Portfolio returns often have low correlations, which indicates a potential for risk reduction through base currency diversification.

FIGURE 2

Correlations of the EM deposit portfolio reported in different currencies (January 2004 to December 2014)

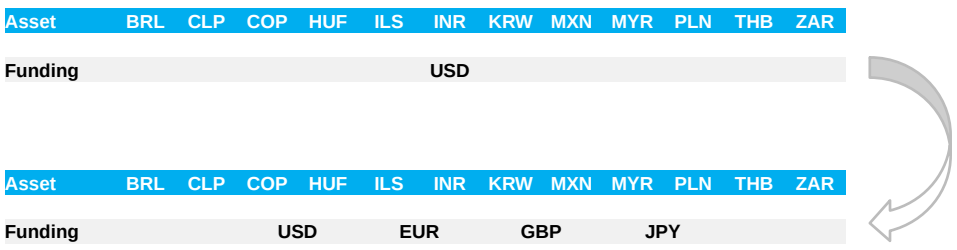
	USD	EUR	GBP	JPY	CAD	AUD	CHF	SEK	SGD	NZD
EUR	0.12									
GBP	0.44	0.29								
JPY	0.65	0.21	0.29							
CAD	0.28	0.02	0.29	0.12						
AUD	-0.47	0.11	-0.04	-0.28	0.10					
CHF	0.16	0.66	0.21	0.38	-0.04	0.02				
SEK	-0.07	0.61	0.26	0.08	0.12	0.21	0.38			
SGD	0.78	0.23	0.38	0.72	0.16	-0.24	0.38	0.05		
NZD	-0.28	0.20	0.04	-0.18	-0.01	0.55	0.25	0.22	-0.15	
NOK	-0.03	0.49	0.26	0.02	0.25	0.22	0.28	0.65	0.03	-0.01

Source: Barclays Research

The FX exposure of an international portfolio can often be viewed as a long position in a basket of foreign currencies (the numerator: investment portfolio) vs. a concentrated short position in the base currency (the denominator: funding). Recognizing that both numerator and denominator can entail significant idiosyncratic risk, we suggest that this risk could potentially be reduced by diversifying base currency exposure in addition to being diversified across investment currencies. The logic of base currency diversification is illustrated in Figure 3 in which the funding of a portfolio is changed from USD-only to a basket of four currencies. This can be implemented by funding the portfolio with a mix of different currencies or, as explained later, with an overlay of currency forwards.

FIGURE 3

Moving from concentrated to diversified funding



Source: Barclays Research

What is the scope for base currency diversification in different asset classes? How are the carry properties of the portfolio affected? What are the factors driving the effectiveness of the diversification?

We discuss case studies based on recent historical data. First, we explain the effect of base currency diversification on the EM deposit portfolio shown above. In the following section, the investment portfolio is changed to EM bonds and then to EM equities. Finally, a technical appendix provides an analytical explanation.

Reducing Portfolio Risk through Base Currency Diversification

To reduce the risk associated with a concentrated exposure to a single base currency, investors can fund the portfolio in several currencies. Equivalently, base currency diversification could be implemented by rolling forward contracts to short several liquid currencies relative to the original base currency. For example, a US investor could diversify base currency by selling a few selected currencies against the USD using forward contracts and rolling positions periodically. Note that none of the selected currencies need be in the investment portfolio.

Diversifying base currency exposure differs from proxy hedging. While the latter generally refers to substituting one currency for another when hedging individual portfolio exposures, base currency diversification aims to diversify the funding leg of the portfolio with only a loose reference to portfolio investments, so that it does not aim to neutralize individual currency exposures. This allows retaining the FX carry premium in the portfolio.

Several factors can play important roles in the choice of funding currencies. The capacity to reduce portfolio risk, the impact on carry, and liquidity are all relevant. The potential for risk reduction is usually large when currency volatility is high relative to the total portfolio volatility. Currencies in which portfolio returns exhibit low correlations are also relevant candidates to diversify funding. The choice of funding currencies can have a significant impact on carry, which may influence return and risk properties. Finally, running a systematic short exposure should generally favour liquid currencies, with low transaction costs so that positions can be rolled efficiently.

To what extent can base currency diversification reduce overall portfolio risk? We consider the EM deposit portfolio discussed in Figure 1 and analyse its historical returns measured in different base currencies. Results reported in Figure 4 compare two scenarios: concentrated base currency and diversified funding basket equally allocated between USD and EUR. Portfolio volatility reported in USD declines from 256bp/m to 167bp/m when funding is equally diversified between USD and EUR. Subsequent rows of Figure 4 show historical performance of the same portfolio reported in different currencies. Note that this change in base currency, meant to illustrate the effect of diversification, is somewhat extreme as it consists of a funding shift away from the original base currency in addition to diversification across EUR and USD.

Figure 4 shows that portfolio volatility declines (except for the SGD) and becomes nearly invariant to the choice of reporting currency when funding is equally allocated to USD and EUR. The invariance of portfolio volatility (close to 170bp/m as shown in the third column of numbers in Figure 4) with respect to the reporting currency results from the fact that the portfolio long (asset) and short (funding) legs are identical irrespective of the currency in which performance is reported. The currency in which returns are expressed has only a second order effect on reported performance.

FIGURE 4

Volatility is generally reduced when funding of the EM deposit portfolio is allocated equally between EUR and USD (January 2004 to December 2014)

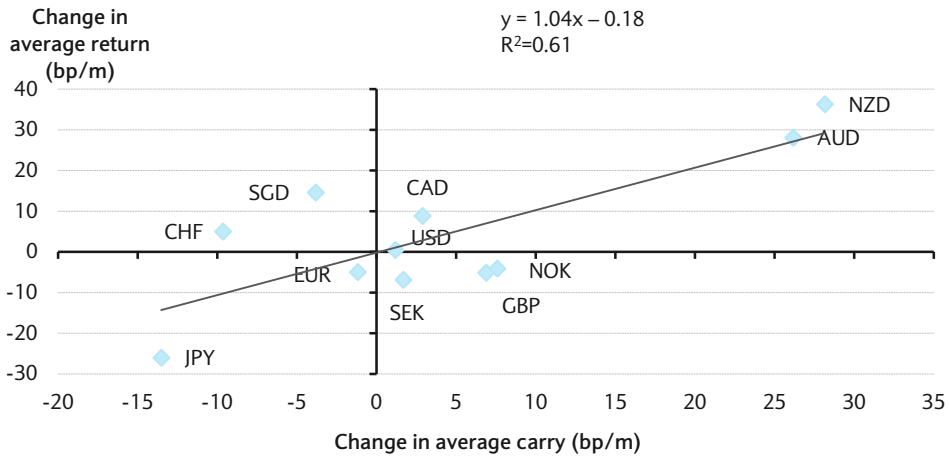
	Base currency is concentrated		Base currency is fully and equally diversified in USD and EUR					
Base	Vol (bp/m)	Avg Excess Return (bp/m)	Vol (bp/m)	% change in volatility	% of time 2-yr vol is reduced	Avg Excess Return (bp/m)	Change in average carry (bp/m)	Change in average return (bp/m)
USD	256	30	167	-35%	97%	30	1	0
EUR	187	33	170	-9%	77%	29	-1	-5
GBP	229	34	169	-26%	83%	29	7	-5
JPY	364	56	167	-54%	100%	30	-14	-26
CAD	210	18	169	-20%	64%	27	3	9
AUD	215	-3	170	-21%	83%	25	26	28
CHF	238	23	170	-28%	78%	28	-10	5
SEK	215	34	170	-21%	73%	28	2	-7
SGD	143	14	168	18%	21%	28	-4	15
NZD	267	-10	171	-36%	82%	26	28	36
NOK	226	32	171	-25%	83%	27	8	-4

Performance is reported in excess of 1M local deposit rates
Source: Barclays Research

For some base currencies, such as the JPY, diversifying funding across EUR and USD reduces carry and realized returns. Indeed, portfolio carry decreases when a low yielding funding currency is replaced with higher yielding ones. Carry may be important when choosing funding currencies to the extent that FX carry can be a predictor of realized returns and is also associated with FX risk properties[3]. The scatter chart in Figure 5 plots the two rightmost columns of Figure 4 and shows that, in the data sample considered, changes in realized returns due to base currency diversification are positively related to changes in FX carry.

FIGURE 5

Changes in FX carry affect realized returns (January 2004 to December 2014)



Source: Barclays Research

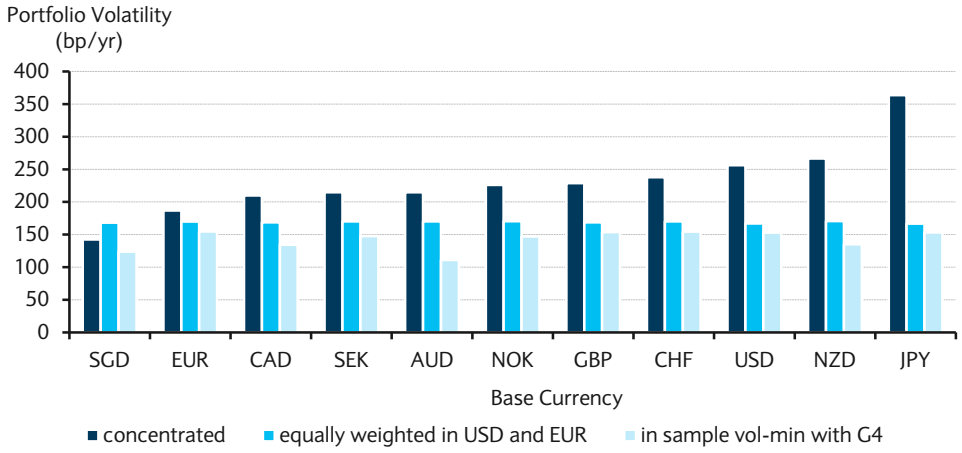
[3] See Ghia K. et al. *The G10 FX Carry Premium*, Barclays Research, November 2010, and Koijen R. et al, Carry, NBER 2013

For most reporting currencies, risk reduction from diversifying funding across USD and EUR is substantial and persistent, as indicated by the large percentage of months when the trailing 24-month return volatility is reduced (see the fifth column of Figure 4). An exception is the SGD, a currency that appears to bear little country-specific risk as its exchange rate is kept within a managed band relative to a basket of major currencies that includes USD and EUR. So, for this low idiosyncratic risk currency, there is only a limited prospect for reducing risk further through base currency diversification. In fact, replacing SGD by an equally weighted basket of USD and EUR does not help in this case. A less naïve strategy would be required to reduce portfolio risk.

As an example of this, Figure 6 shows the potential for further risk reduction of a volatility-minimizing strategy that diversifies funding across G4 currencies (USD, EUR, JPY, and GBP) in addition to the reporting one. Weights are kept unchanged throughout the entire period and determined in-sample by minimizing overall portfolio volatility.

FIGURE 6

Volatility of the EM deposit portfolio could be further reduced by expanding the funding universe to G4 currencies and minimizing portfolio risk (January 2004 to December 2014)

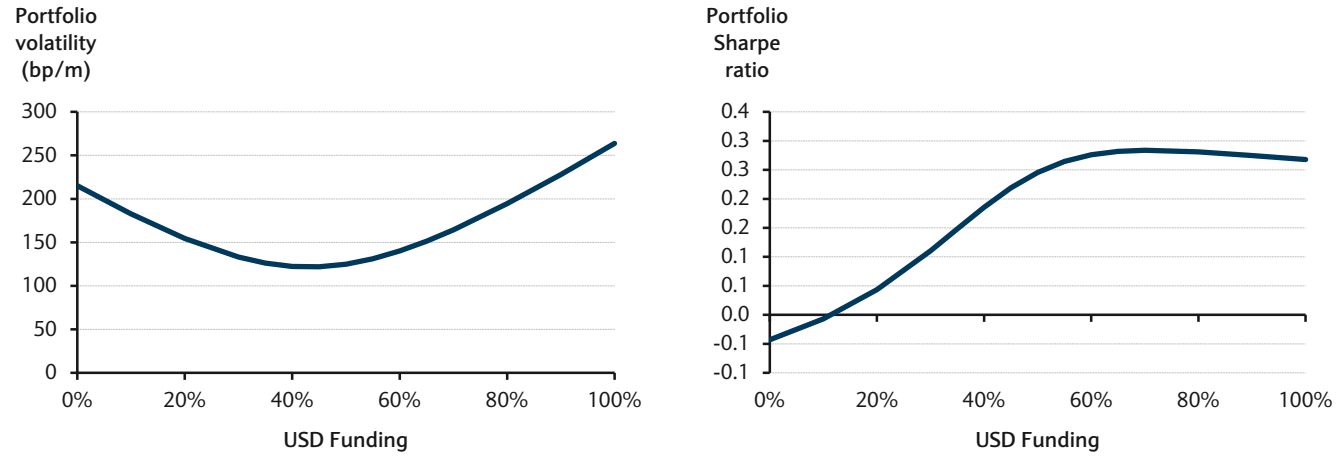


Source: Barclays Research

As we saw in Figure 2, portfolio returns expressed in different base currencies are imperfectly correlated. The average correlation across eleven developed market currencies is only 19%. Negatively correlated currency pairs could be combined into a funding basket to substantially reduce portfolio volatility. For example, portfolio returns expressed in AUD and USD have a sample correlation of -47%. This implies that an AUD-based investor could have reduced risk significantly by partially funding his portfolio in USD. In practice, this can be implemented by selling USD forward vs. AUD and rolling the position periodically. As shown in Figure 7, adding USD to the funding leg of the portfolio reduces volatility from 215bp/m to 125bp/m for a 50%-USD funding. The portfolio Sharpe ratio improves as, in the considered period, shorting USD relative to AUD benefited portfolio carry and realised returns: average realized excess return over 1M AUD deposit increases from -3 to 9bp/m when USD funding goes from 0 to 50%.

FIGURE 7

An AUD-based investor could reduce volatility and improve Sharpe ratio of the EM deposit portfolio by diversifying funding into USD (January 2004-December 2014)



Source: Barclays Research

Effect of Base Currency Diversification on Bond and Equity Portfolios

Having discussed the case of an EM deposit portfolio, we now study the effect of base currency diversification on global bond and equity portfolios. In both cases, we consider equally weighted portfolios that invest in the same 12 EM markets as those discussed previously. We report performance in the same 11 developed market currencies as in the previous section so that the asset portfolio does not overlap with the universe of funding (base) currencies[4]. We study different alternatives for base currency diversification and report their effect on portfolio performance over the past 11 years.

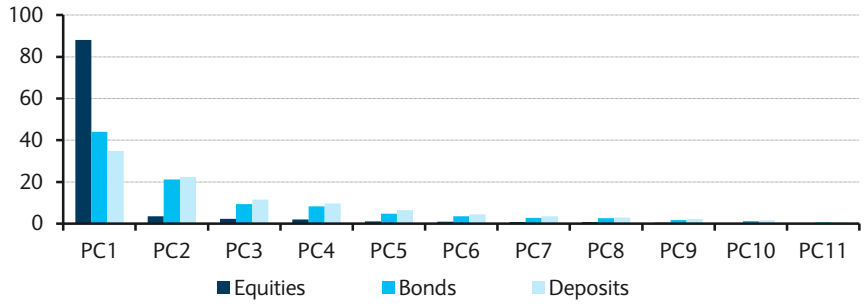
The effect of base currency diversification can vary significantly depending on the composition of the underlying investment portfolio. The scope for risk reduction depends on relative volatilities and correlations of asset and FX returns. As FX volatility is typically high relative to bonds, currency exposure can have a significant impact on the performance of bond portfolios. On the other hand, equity volatility is generally higher than FX volatility, meaning that currency exposure could be expected to have a smaller effect on the risk of equity portfolios.

To assess the scope for base currency risk diversification in different markets, we perform a principal component analysis of the covariance matrix of portfolio returns measured in different base currencies. The analysis is repeated for three asset portfolios: EM deposits, bonds and equities. Figure 8 indicates that for the equity portfolio, a single factor explains close to 90% of the variance as equity risk indeed dominates irrespective of the choice of currency in which performance is reported. This risk associated with equity markets would be hard to reduce by diversifying portfolio funding. On the other hand, for bond or deposit portfolios we do not observe a single dominant risk factor. On the contrary, multiple factors are necessary to explain covariances. This indicates a potential for reducing portfolio risk through base currency diversification.

[4] If asset and funding universes overlapped, some FX exposures could cancel out. This would be equivalent to currency-hedging (part of) the investment portfolio. We choose to avoid discussing currency hedging ratios, and rather take the view that foreign currency exposure embedded in the investment portfolio is desirable.

FIGURE 8

Share of variance explained by principal components for portfolios of equities, bonds and deposits reported in different base currencies



Source: Barclays Research

The correlation between currency and asset returns can also be an important risk reduction mechanism. If the portfolio invests in equity-like assets, funding with currencies that are positively correlated with equity markets (e.g., high yielding currencies) should help reduce risk. On the other hand, if the portfolio invests in bonds, funding with "safe haven" (and typically low carry) currencies that are positively correlated with bond returns should help reduce volatility.

The following examples illustrate the impact of base currency diversification in the context of bond and equity portfolios.

1. **Emerging Market Local Currency Bonds**

In this example, the investment portfolio consists of an equally weighted basket of 12 local currency EM bond indices.[5] Figure 9 compares currency volatility with bond market volatility in this portfolio, with each row representing the same portfolio of EM bonds expressed in a different base currency. It is clear that currency risk dominates: isolated FX volatilities, ranging from 143 to 364bp/m, significantly exceed those of fully hedged portfolio returns of the order of 88bp/m. One can therefore expect changes in currency exposure to have a significant effect on overall portfolio risk.

FIGURE 9

Currency volatility dominates bond market volatility (January 2004 to December 2014)

Base Currency	Currency volatility in isolation (bp/m)	Fully FX hedged bond market volatility (bp/m)	Correlation of FX returns with bond returns	Portfolio volatility when base currency is concentrated (bp/m)
USD	256	88	37%	300
EUR	187	86	23%	223
GBP	229	90	50%	284
JPY	364	87	10%	383
CAD	210	89	10%	236
AUD	215	87	-16%	219
CHF	238	86	18%	267
SEK	215	88	21%	249
SGD	143	87	29%	187
NZD	267	88	-5%	277
NOK	226	89	22%	261

Performance is reported in excess of 1M local deposit rates. Source: Barclays Research

[5] We take 3-7yr maturity and country sectors of the Barclays Local Currency Government Universal Bond Index and, in some cases, extend time series with returns estimated from local bond yields published by corresponding central banks and sourced from Datastream. As in the previous section, the portfolio is equally weighted across BRL, CLP, COP, HUF, ILS, INR, KRW, MXN, MYR, PLN, THB, and ZAR.

Figure 10 reports historical performance of the bond portfolio under two scenarios: the portfolio is funded with a single base currency, or it is funded with an equally weighted basket of EUR and USD. Taking the USD as an example (first row of Figure 10), portfolio volatility drops from 300bp/m to 218bp/m when diversifying funding equally between USD and EUR. Although portfolio volatility is reduced by 28%, it remains much higher than the 88bp/m of the fully hedged EM portfolio as significant exposure to FX remains.

In some cases (EUR, AUD, SGD) portfolio volatility does not materially decline as a result of switching to the basket of funding currencies. This is due to two effects observed in our sample. First, the isolated volatility of the basket of underlying EM currencies is higher when expressed in USD (256bp/m) than when reported in the original base currency. This effect is particularly important when shifting funding away from EUR or SGD as the portfolio returns measured in these two currencies have low volatilities of 187 and 143bp/m, respectively. Second, the correlation between EM bond returns and isolated FX returns is stronger when expressed in USD than in almost all other currencies (see third column of Figure 9). This is consequential when changing from AUD funding (correlation of -16% with EM bonds) to a funding strategy that includes USD (37% correlated with EM bonds).

Although realised historical returns do not always improve, the naïve USD-EUR funding strategy helped increase Sharpe ratio for 10 out of the 11 base currencies considered, the EUR being the exception. The reduction in volatility is the largest from the perspective of a JPY investor (from 383 to 218bp/m: -43%). Excess returns over local 1M deposit rates become similar across all reporting currencies and, in some cases, are significantly enhanced. This is the case, for example, for AUD and NZD. Changing portfolio funding from these relatively high yielding currencies to an equally weighted basket of USD and EUR improves carry. This helps enhance portfolio realized return and Sharpe ratio in our sample.

FIGURE 10

Risk and returns of the EM local currency bond portfolio measured in different base currencies (January 2004 to December 2014)

	Base currency is concentrated			Base currency is fully and equally diversified in USD and EUR				
	Vol (bp/m)	Avg Exc. Return (bp/m)	Sharpe ratio	Vol (bp/m)	% change in volatility	% of time 2-yr vol is reduced	Avg Exc. Return (bp/m)	Sharpe ratio
USD	300	54	0.62	218	-28%	95%	54	0.86
EUR	223	57	0.88	220	-1%	51%	52	0.82
GBP	284	58	0.70	219	-23%	83%	53	0.83
JPY	383	80	0.72	218	-43%	100%	54	0.86
CAD	236	42	0.61	219	-7%	63%	51	0.80
AUD	219	20	0.32	220	1%	51%	48	0.76
CHF	267	47	0.61	219	-18%	73%	52	0.82
SEK	249	58	0.81	220	-11%	67%	51	0.80
SGD	187	37	0.68	218	17%	18%	52	0.82
NZD	277	13	0.16	221	-20%	68%	49	0.77
NOK	261	55	0.73	221	-15%	73%	51	0.80

Performance is reported in excess of 1M local deposit rates. Source: Barclays Research

Let us now consider a funding strategy explicitly designed to reduce overall portfolio risk. For each original base currency, the funding universe is augmented by including G4 currencies. The allocation of the funding basket is updated every month by taking weights that minimize portfolio volatility in the prior 36 months. The performance of this simple out-of-sample dynamic weighting scheme is reported in Figure 11 and then further detailed in Figure 12. As in the previous case, the entire sample volatility is generally reduced, as are most of the rolling 2y volatilities (with the exception of SGD). Sharpe ratios appear to increase significantly due to risk reduction as well as, in most cases, an improvement in realised return.

FIGURE 11

Optimizing base currency allocation can reduce volatility and improve bond portfolio Sharpe ratios (January 2004 to December 2014)

	Base currency is concentrated			Base currency minimises portfolio volatility out-of-sample using G4 currencies				
	Vol (bp/m)	Avg Exc. Return (bp/m)	Sharpe ratio	Vol (bp/m)	% change in volatility	% of time 2-yr vol is reduced	Avg Exc. Return (bp/m)	Sharpe ratio
USD	300	54	0.62	219	-27%	94%	65	1.03
EUR	223	57	0.88	219	-2%	75%	64	1.01
GBP	284	58	0.70	221	-22%	95%	65	1.02
JPY	383	80	0.72	219	-43%	99%	65	1.03
CAD	236	42	0.61	193	-18%	98%	57	1.03
AUD	219	20	0.32	164	-25%	99%	35	0.74
CHF	267	47	0.61	216	-19%	86%	63	1.02
SEK	249	58	0.81	219	-12%	64%	66	1.05
SGD	187	37	0.68	191	2%	48%	54	0.97
NZD	277	13	0.16	198	-28%	95%	45	0.79
NOK	261	55	0.73	221	-15%	82%	70	1.10

Performance is reported in excess of 1M local deposit rates. Source: Barclays Research

In the context of our bond portfolio example, minimizing portfolio volatility resembles a carry enhancing strategy, and the carry advantage that results from funding with low yielding G4 currencies helps increase average return in most cases, except for JPY, where return decreased from 80 to 65bp/m. Figure 12 provides a detailed attribution of the returns delivered by out-of-sample risk minimization. In the original portfolio, the contribution of FX carry is very significant (first column of Figure 12). A large portion of that carry is retained, in most cases, as spot FX returns (column 2 of Figure 12) are not low enough to negate it. The effect of diversification varies across reporting currencies. For a Japanese investor, diversifying funding into higher yielding FX reduces carry (by 12bp) and return (by 15bp) but the opposite is true for AUD and NZD-based investors: the initially low carry and return of EM FX, when measured in these two currencies, increase as funding is diversified across G4 markets.

In the sample considered, the risk minimisation strategy also helped increase Sharpe ratios of isolated FX returns (rightmost column of Figure 12). Higher FX Sharpe ratios together with a slightly improved risk allocation between FX carry and bond term premium led to higher risk-adjusted returns for the bond portfolio.

FIGURE 12

Attributing performance of base currency diversification when portfolio volatility is minimized out-of-sample using G4 currencies (January 2004 to December 2014)

Base	Original FX carry	Original FX spot return	Incremental carry	Incremental spot FX return	Incremental return	Change in Isolated FX risk	Original FX S.R.	New FX S.R.
USD	27	2	3	9	12	-36%	0.40	0.87
EUR	30	4	1	6	7	-11%	0.62	0.84
GBP	22	12	9	-2	7	-28%	0.51	0.85
JPY	42	14	-12	-3	-15	-55%	0.54	0.87
CAD	26	-7	3	13	16	-31%	0.30	0.82
AUD	2	-5	14	0	15	-43%	-0.04	0.34
CHF	38	-15	-7	24	17	-31%	0.34	0.85
SEK	27	8	3	6	8	-24%	0.56	0.91
SGD	32	-19	0	17	17	-2%	0.33	0.76
NZD	0	-11	22	11	33	-43%	-0.13	0.51
NOK	21	11	6	8	15	-27%	0.48	0.97

Source: Barclays Research

2. Emerging Market Equities

Similarly to our bond portfolio example, we use an EM equity portfolio equally weighted across the 12 markets discussed in the previous sections. There is no overlap between investment currencies and base currencies. As shown in Figure 13, currency risk is dominated by equity market risk. Because of this, any reduction in isolated currency volatility is likely to have only a small effect on overall portfolio risk. However, the correlation between FX and equity returns is likely to affect portfolio risk significantly.

FIGURE 13

Currency volatility is lower than equity market volatility (January 2004 to December 2014)

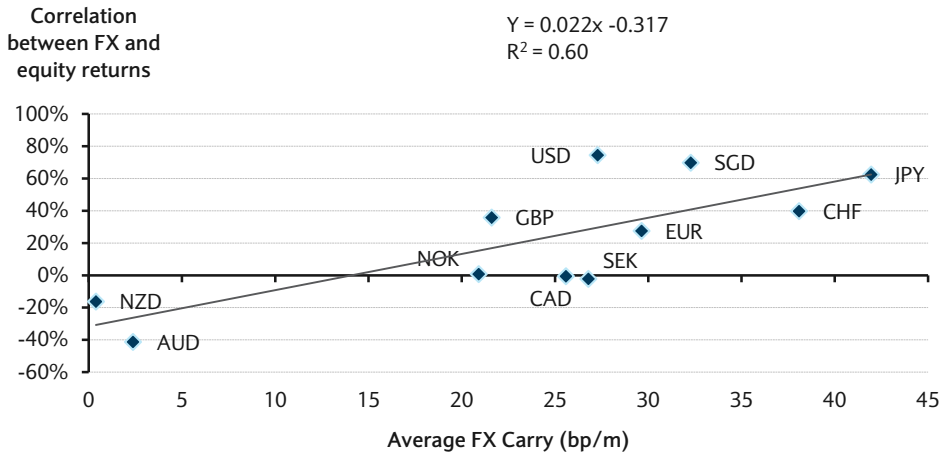
Base Currency	Currency volatility (bp/m)	FX-hedged Equity market volatility (bp/m)	Correlation of currency returns with equity returns	Portfolio volatility when base currency is concentrated (bp/m)
USD	256	426	75%	640
EUR	187	432	28%	516
GBP	229	431	36%	556
JPY	364	419	63%	706
CAD	210	433	-1%	480
AUD	215	437	-41%	399
CHF	238	427	40%	565
SEK	215	432	-2%	478
SGD	143	427	70%	536
NZD	267	434	-16%	471
NOK	226	435	1%	492

Source: Barclays Research

We also verify that FX carry is related to the correlation of currency returns with equities, consistently with previous empirical findings on the correlation of FX carry trades and equity market returns. In our context, Figure 14 shows that borrowing in a currency that provides high funding carry (i.e., low yielding currency such as the JPY) produces returns that are positively correlated with EM equity returns.

FIGURE 14

FX funding carry is related to correlation with equity returns (January 2004 to December 2014)



Sources: MSCI Equity Indices; Bloomberg; Barclays Research

Given that portfolio risk is dominated by equities, controlling isolated currency risk can only have a limited effect on overall portfolio risk. In equity portfolios, a more effective way of reducing portfolio risk is to design the currency exposure in such a way that its correlation with equity returns is negative. Some (low yielding) currencies are negatively correlated with equity markets, while others (high yielding) are positively correlated. Funding a portfolio with low yielding currencies can thus increase overall portfolio risk.

So, base currency diversification strategies can perform very differently depending on their carry and correlation properties. Figure 15 compares two naïve strategies. The first one, in the middle section of the table, assumes that the portfolio is funded with an equally weighted basket of USD and EUR (G2) while the second one uses four higher yielding currencies (AUD, CAD, SEK and NOK), also equally weighted. Funding the equity portfolio with this new basket can be expected to reduce portfolio risk given lower correlations of funding returns with equity returns.

The USD-EUR funding strategy delivers portfolio volatilities of the order of 560bp/m, substantially higher than the isolated equity market volatility (close to 430bp/m as shown in Figure 13). It reduces risk only for USD and JPY-based investors. In all other cases of G2 funding, portfolio risk is higher than with concentrated funding. Interestingly, SGD is no longer the lowest risk base currency. Its close relationship with G4 currencies makes it directional on equities. The lowest base currency risk is now found for the AUD (399bp/yr, as shown in the first column of Figure 15) because, when it is used as a funding currency, the correlation between equity and FX returns is significantly negative (-41%).

Funding with the basket of higher yielding currencies provides larger risk reductions. Portfolio volatilities are now almost identical to that of the fully hedged portfolio. However, Sharpe ratios (shown in the second rightmost column of Figure 15) are slightly higher than those of FX hedged equities (shown in the rightmost column of Figure 15) because the portfolio could retain EM FX carry, which translated into a return advantage in our sample.

FIGURE 15

Risk and returns of an EM equity portfolio from various base perspectives (January 2004 to December 2014)

	Base currency is concentrated			Base currency is equally diversified in USD and EUR				Base currency is equally weighted in CAD, AUD, SEK and NOK				Fully FX hedged portfolio
Base	Vol (bp/m)	Avg Exc. Return (bp/m)	Sharpe ratio	Vol (bp/m)	% change in vol	Avg Exc. Return (bp/m)	Sharpe ratio	Vol (bp/m)	% change in vol	Avg Exc. Return (bp/m)	Sharpe ratio	Sharpe ratio
USD	640	82	0.44	559	-13%	82	0.51	429	-33%	67	0.55	0.42
EUR	516	80	0.53	568	10%	75	0.45	434	-16%	63	0.50	0.37
GBP	556	81	0.50	566	2%	76	0.46	432	-22%	64	0.51	0.38
JPY	706	110	0.54	552	-22%	84	0.53	424	-40%	70	0.57	0.44
CAD	480	62	0.45	567	18%	71	0.43	434	-10%	61	0.49	0.35
AUD	399	37	0.32	573	44%	65	0.40	437	9%	57	0.46	0.32
CHF	565	71	0.44	563	0%	76	0.47	430	-24%	64	0.52	0.39
SEK	478	78	0.56	569	19%	71	0.43	435	-9%	62	0.49	0.35
SGD	536	62	0.40	561	5%	76	0.47	429	-20%	64	0.52	0.39
NZD	471	31	0.23	571	21%	68	0.41	436	-7%	59	0.47	0.33
NOK	492	75	0.53	571	16%	71	0.43	436	-11%	62	0.49	0.35

Performance is reported in excess of 1M local deposit rates. Sources: MSCI Equity Indices; Bloomberg; Barclays Research

As in the previous case study, we also investigate a simple out-of-sample risk minimization strategy. The weights of funding currencies are updated every month by minimizing portfolio volatility in the prior three years. The funding universes include the domestic currency plus either G4 (low carry currencies) or the higher yielding four currencies. Results are shown in Figure 16. Funding with G4 currencies does not reduce risk much but does improve Sharpe ratios in most cases. The alternative funding strategy reduces risk to roughly 400bp/m, well below the volatility of the fully hedged basket of equity indices (close to 430bp/m) and of the naïve, equal weighting allocation shown in Figure 15. But average returns and Sharpe ratios become generally lower. In this case, minimizing portfolios risk using high yielding currencies delivers lower Sharpe ratios than using a naïve, equally weighted funding basket of these same four currencies (Sharpe ratios are roughly 0.15 lower across all currencies), although portfolio volatilities are indeed lower, as expected. In fact, reducing risk by funding the portfolio with higher yielding currencies is detrimental to portfolio return in the period considered. It also affects the balance of risk between FX carry premium and equity risk premium, making the portfolio less efficient. This is not surprising given that equity risk dominates, while EM FX and EM Equities generated similar Sharpe ratios in the period considered.

FIGURE 16

Optimizing base currency allocation can reduce volatility of an EM equity portfolio (January 2004 to December 2014)

	Base currency is concentrated			Base currency minimises portfolio volatility out-of-sample using G4 currencies				Base currency minimises portfolio volatility out-of-sample using CAD, AUD, SEK and NOK			
	Vol (bp/m)	Avg Exc. Return (bp/m)	Sharpe ratio	Vol (bp/m)	% change in volatility	Avg Exc. Return (bp/m)	Sharpe ratio	Vol (bp/m)	% change in volatility	Avg Exc. Return (bp/m)	Sharpe ratio
USD	640	82	0.44	528	-18%	95	0.62	399	-38%	46	0.40
EUR	516	80	0.53	532	3%	89	0.58	402	-22%	41	0.36
GBP	556	81	0.50	531	-4%	91	0.59	402	-28%	42	0.36
JPY	706	110	0.54	523	-26%	96	0.64	396	-44%	48	0.42
CAD	480	62	0.45	486	1%	62	0.44	402	-16%	39	0.34
AUD	399	37	0.32	403	1%	37	0.32	405	1%	39	0.33
CHF	565	71	0.44	527	-7%	90	0.59	399	-29%	43	0.38
SEK	478	78	0.56	490	2%	78	0.55	404	-16%	39	0.34
SGD	536	62	0.40	532	-1%	80	0.52	399	-26%	43	0.37
NZD	471	31	0.23	480	2%	39	0.28	407	-14%	35	0.30
NOK	492	75	0.53	507	3%	79	0.54	404	-18%	39	0.34

Performance is reported in excess of 1M local deposit rates. Sources: MSCI Equity Indices; Bloomberg; Barclays Research

Conclusion

Many investors run international portfolios relative to a single domestic base currency so that currency risk typically reflects the combination of two legs: a diversified portfolio of foreign currencies and a concentrated position in a base currency. But, a global portfolio is vulnerable to a scenario in which the base currency appreciates relative to the rest of the world, devaluing the whole portfolio at once. Shocks to the valuation of a domestic currency can be triggered by country-specific economic or monetary factors.

At the same time, investors might be reluctant to hedge foreign currencies, considering their carry properties as a desirable source of incremental return. So, to reduce exposure to base currency shocks, we advocate that both funding and investment legs of a currency portfolio be diversified.

Base currency diversification can be implemented by selling additional funding currencies against the original concentrated base currency in forward contracts that are rolled periodically. This is equivalent to financing the portfolio with a basket of currencies.

We analyse emerging market portfolios investing in cash, bonds or equities and consider simple strategies to diversify base currency risk. We find that diversifying base currency risk can effectively reduce risk and potentially improve the performance of cash and bond portfolios, where currency risk dominates asset return volatility.

In equity portfolios, FX has a relatively small contribution to portfolio risk. As a result, controlling isolated FX risk has only a small effect on overall portfolio risk and FX-equity correlation, which is related to carry, can have a more significant effect on portfolio risk. Diversifying portfolio risk can still help transform the FX carry premium embedded in the portfolio and deliver higher Sharpe ratios than fully hedged equity allocations.

Appendix: An Analytical Explanation

Consider asset *i* denominated in currency *i*.[6] Its excess return over the domestic short rate can be written as a combination of local return of the asset and foreign currency return[7]

$$R_i \approx \{r_i - r_0 + F\beta_i + \varepsilon_i\} + \{H\gamma_i + \omega_i\}$$

- Foreign currency returns: $\{r_i - r_0 + F\beta_i + \varepsilon_i\}$,

  where r_i and r_0 are foreign and domestic short rates respectively; F is the vector of systematic currency risk factors; β_i is the vector of loadings on the systematic FX factors, and ε_i is the idiosyncratic part of FX return.

- Local excess return of the asset over deposit rate: $\{H\gamma_i + \omega_i\}$,

  where H is the vector of systematic risk factors driving asset returns; γ_i is the vector of exposures of asset *i* to the systematic factors; and ω_i is the idiosyncratic return of asset *i* in currency *i*.

The choice of the base currency can be represented as selling that currency relative to the previous (original) numeraire. So, if an investor selects currency *j* as a new numeraire, the return on asset *i* becomes:

$$R_i^j \approx \{H\gamma_i + \omega_i\} + \{r_i^j + F\beta_i^j + (\varepsilon_i - \varepsilon_j)\}$$

where we denoted $r_i^j = r_i - r_j$ and $\beta_i^j = \beta_i - \beta_j$

And the return of a portfolio of assets with weights w_i expressed in terms of currency j becomes:

$$R_p^j \approx r_p^j + H\gamma_p + F\beta_p^j + \sum_{i\in I} w_i\varepsilon_i + \sum_{i\in I} w_i\omega_i - \varepsilon_j$$

where

$r_p^j = \sum_{i\in I} w_i r_i^j$ is the portfolio short-term carry;

$\gamma_p = \sum_{i\in I} w_i\gamma_i$ is the vector of portfolio exposures to systematic asset factors;

$\beta_p^j = \sum_{i\in I} w_i\beta_i^j$ is the vector of portfolio exposures to systematic currency factors;

Note that, for simplicity, the portfolio does not hold any assets denominated in the new base currency *j*, i.e. $j \notin I$.

The two equations above reveal a couple of interesting observations:

- Correlations between different foreign assets are driven by (a) their exposures to systematic asset and currency factors and (b) their exposure to the idiosyncratic component ε_j of base currency *j*.

- While the idiosyncratic risk of *portfolio* currencies can be reduced by including more assets (currencies) into the portfolio, the idiosyncratic *risk of the base currency* remains.

To validate these two observations, we write the expressions for covariance of currency returns and portfolio variance:

[6] Without loss of generality we apply the same indexation for assets and currencies.
[7] We make a simplification by ignoring the cross-term between FX and asset returns in these calculations. It has a second order effect.

$$\mathrm{Cov}\left(R_i^j, R_k^j\right) = \begin{cases} \gamma_i^T \Sigma_{HH} \gamma_i \ + \beta_i^{jT} \Sigma_{FF} \beta_i^j + 2\gamma_i^T \Sigma_{HF} \beta_i^j + \sigma_j^2 + \sigma_i^2 & \text{if } i = k \\ \gamma_i^T \Sigma_{HH} \gamma_k \ + \beta_i^{jT} \Sigma_{FF} \beta_k^j + \gamma_i^T \Sigma_{HF} \beta_k^j + \beta_i^{jT} \Sigma_{FH} \gamma_k \ + \sigma_j^2 & \text{if } i \neq k \end{cases}$$

The expression for portfolio variance is:

$$V_p^j = \gamma_p^T \Sigma_{HH} \gamma_p \ + \beta_p^{jT} \Sigma_{FF} \beta_p^j + 2\gamma_p^T \Sigma_{HF} \beta_p^j + \sum_{i \in I} w_i^2 \left(\sigma_i^2 + \delta_i^2\right) + \sigma_j^2$$

where σ_i is the idiosyncratic volatility of currency *i* and δ_i is the idiosyncratic volatility of asset *i*.

Under certain regularity conditions on portfolio weights, the second part of the expression above converges to idiosyncratic variance of the base currency as the asset portfolio becomes more diversified:

$$\lim_{I \to \infty} \sum_{i \in I} w_i^2 \left(\sigma_i^2 + \delta_i^2\right) + \sigma_j^2 = \sigma_j^2$$

When the portfolio becomes more diversified, its risk becomes predominantly driven by: (a) the systematic risk of currency and asset factors and (b) the idiosyncratic risk of the base currency. The systematic risk of the portfolio can be small if correlations between currency and asset factors are negative (we discuss this point later).

If the portfolio is funded from a basket of currencies instead of a single "base" currency, the idiosyncratic risk of the numeraire is also diversified and portfolio risk declines. In particular, assuming for simplicity that portfolio currencies and the numeraire basket do not overlap ($J \cap I = \emptyset$), the formula for portfolio returns becomes:

$$R_p^J = \sum_{i \in I} w_i R_i - \sum_{i \in J} h_j R_j = r_p^J + H\gamma_p + F\beta_p^J + \sum_{i \in I} w_i \omega_i + \left(\sum_{i \in I} w_i \varepsilon_i - \sum_{j \in J} h_j \varepsilon_j \right)$$

where $\{w_i\}$ are the weights of portfolio currencies, and $\{h_j\}$ are the weights of funding (numeraire) currencies. We also introduce new notations for portfolio exposures to systematic currency factors: $\beta_p^J = \sum_{i \in I} w_i \ \beta_i \ - \sum_{j \in J} h_j \ \beta_j$. The expression for portfolio risk becomes:

$$V_p^J = \gamma_p^T \Sigma_{HH} \gamma_p \ + \beta_p^{JT} \Sigma_{FF} \beta_p^J + 2\gamma_p^T \Sigma_{HF} \beta_p^J + \sum_{i \in I} w_i^2 \left(\sigma_i^2 + \delta_i^2\right) + \sum_{j \in J} h_j^2 \sigma_j^2$$

It is clear that under regularity conditions, the idiosyncratic currency risk of the portfolio declines when the portfolio and the basket of funding currencies become more diversified. Moreover, for a finite set of systematic factors driving currency returns, it should be possible to find a set of base currencies that reduces the systematic risk of the portfolio. This can be achieved by ensuring that systematic exposures of the portfolio and the numeraire basket are similar: $\beta_p^J \approx 0$.

Example 1: Idiosyncratic Currency Risk

Let us assume the following:

- No asset risk
- A single systematic factor in all currency returns
- All currencies have a unit exposure to this systematic factor
- Idiosyncratic volatility is identical for all currencies

Then, the returns of any currency consist of a systematic and an idiosyncratic part, both equally risky:

$$R_i = f + \varepsilon_i,$$

$$\sigma_i^2 = \sigma_j^2 = \sigma_f^2 = \sigma^2$$

The covariance between any two currencies i and k is:

$$\mathrm{Cov}(R_i, R_k) = \begin{cases} 2\sigma^2 & \text{if } i = k \\ \sigma^2 & \text{if } i \neq k \end{cases}$$

While a portfolio of N equally weighted currencies has a variance of

$$V_p = \left(1 + \frac{1}{N}\right)\sigma^2$$

If we change the base currency to currency j, currency returns can be re-written as the difference between the idiosyncratic parts of the investment and the numeraire currency, as the systematic part cancels out:

$$R_i^j = \varepsilon_i - \varepsilon_j.$$

Note that even though exposure to the systematic risk factor cancels out, the idiosyncratic part of the new base currency becomes a new source of systematic risk for all portfolio currencies which all are expressed in terms of the new base. As a result, the covariance between any two currencies does not change:

$$\mathrm{Cov}\left(R_i^j, R_k^j\right) = \begin{cases} 2\sigma^2 & \text{if } i = k \\ \sigma^2 & \text{if } i \neq k \end{cases}$$

The returns of the equally weighted portfolio of N currencies relative to the new base are

$$R_p^j = \frac{1}{N}\sum_{i \in I} \varepsilon_i - \varepsilon_j$$

Portfolio variance remains unchanged, and a function of base currency idiosyncratic risk:

$$V_p^j = \left(\frac{1}{N} + 1\right)\sigma^2$$

Now, if we diversify funding sources so that the numeraire becomes an equally weighted basket of m currencies, individual currency returns become:

$$R_i^J = \varepsilon_i - \frac{1}{m}\sum_{j \in J} \varepsilon_j$$

The covariance between returns of any two currencies becomes:

$$\mathrm{Cov}\left(R_i^J, R_k^J\right) = \begin{cases} \left(1 + 1/m\right)\sigma^2 & \text{if } i = k \\ \sigma^2/m & \text{if } i \neq k \end{cases}$$

The returns of an equally weighted portfolio of N investment currencies can then be written as:

$$R_p^J = \frac{1}{N}\sum_{i \in I} \varepsilon_i - \frac{1}{m}\sum_{j \in J} \varepsilon_j$$

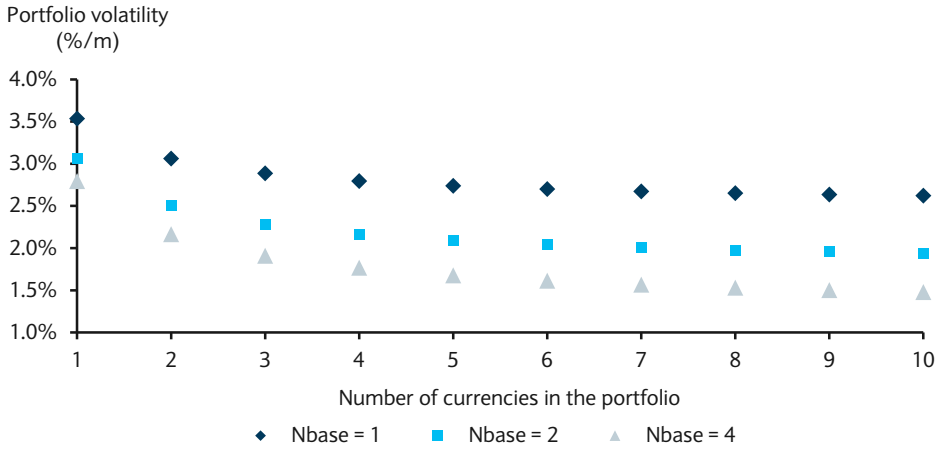
And portfolio variance is:

$$V_p^J = \left(\frac{1}{N} + \frac{1}{m}\right)\sigma^2$$

Note that both individual currency covariance and overall portfolio variance decline with the number of currencies in the numeraire basket. We call this effect *base currency risk diversification*. This is illustrated in Figure 17 which shows the relationship between portfolio volatility and portfolio concentration. We assume that all currencies have an idiosyncratic volatility of 2.5%/month and show the effect of diversifying base currency (the numeraire) in portfolios that are concentrated (left hand side of the chart) or diversified in up to 10 foreign currencies (right hand side of Figure 17).

FIGURE 17

Portfolio volatility is reduced when base currency risk is diversified



Source: Barclays Research

Example 2: Role of Correlation between Currency and Asset Returns

Correlations between currency and asset returns, as well as their relative volatilities, can significantly affect the risk of an international portfolio funded with a diversified basket of numeraire currencies. A simple model can help represent the role of this correlation. Let us assume the following:

- A single systematic factor *g* for all asset returns
- Two systematic factors for currency returns
    - All asset currencies are exposed to factor *f*
    - All funding currencies are exposed to factor *z*
- Idiosyncratic asset and currency returns

The returns of asset *i* denominated in currency *i* can then be written as:

$$R_i = g + f + \omega_i + \varepsilon_i$$

where g is the systematic factor of asset returns; f is the systematic factor of currency returns; ω_i is the idiosyncratic component of asset returns; and ε_i is the idiosyncratic component of currency returns.

If we chose currency *j* as a new base currency, asset returns become:

$$R_i^j = g + \xi + \omega_i + \varepsilon_i - \varepsilon_j$$

where $\xi = f - z$ is the systematic currency factor obtained as the difference between systematic factors of asset and funding currencies.

For an equally weighted portfolio of assets:

$$R_p^j = g + \xi + \frac{1}{N}\sum_{i\in I}\omega_i + \frac{1}{N}\sum_{i\in I}\varepsilon_i - \varepsilon_j$$

An equally weighted portfolio of *N* assets funded with an equally weighted basket of *m* currencies can be represented as:

$$R_p^J = g + \xi + \frac{1}{N}\sum_{i\in I}\omega_i + \frac{1}{N}\sum_{i\in I}\varepsilon_i - \frac{1}{m}\sum_{j\in J}\varepsilon_j$$

This can be further simplified by making the following assumptions:

- Same systematic and idiosyncratic currency volatilities: $\sigma(\xi) = \sigma(\varepsilon_i) = \sigma$
- Same systematic and idiosyncratic asset volatilities: $\sigma(g) = \sigma(\omega_i) = \alpha\sigma$
- Asset-currency correlation: $\mathrm{Corr}(g, \xi) = \rho$

Using these assumptions, portfolio variance can be written as:

$$V(R_p^J) = \sigma^2\left[1 + \alpha^2 + 2\alpha\rho + \frac{(1+\alpha^2)}{N} + \frac{1}{m}\right]$$

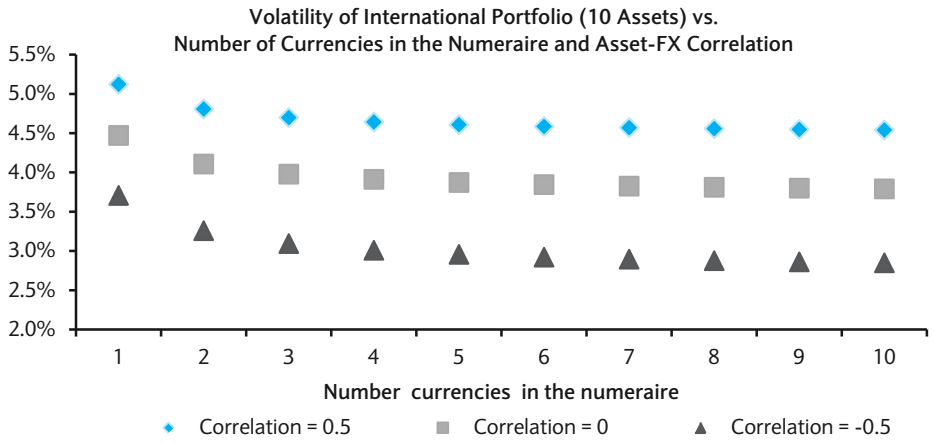
The equation suggests that idiosyncratic base currency risk is still reduced as more currencies are added to the funding basket (as in the previous example). However, the relative magnitude of reduction depends on (a) the ratio of systematic asset and currency volatilities α; and (b) the correlation of systematic asset and currency factors. Let us assume that the asset-currency volatility ratio is $\alpha = 1$ and consider two cases:

In the first case, the correlation between asset and currency returns is negative: $\rho < 0$. This typically happens when the portfolio invests in assets such as government bonds. In the second case, the correlation between asset and currency returns is positive: $\rho > 0$. This is the case when the portfolio invests in risky assets such as equities.

Figure 18 shows that portfolio volatility can benefit from base currency diversification even when currency exposure and portfolio assets are positively correlated. However, the percentage reduction in portfolio volatility is significantly larger when the correlation between asset and currency returns is negative. As in the example shown in Figure 17, we assume that all currencies have the same idiosyncratic volatility of 2.5%/m.

FIGURE 18

Portfolio risk is reduced when base currency risk is diversified



Source: Barclays Research

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