SMART CURRENCY HEDGING FOR SMART BETA GLOBAL EQUITIES

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We investigate whether structurally hedging the currency risk of global equity products benefits long-term investors. Based on a 35 year back-test of 3 smart beta strategies from 6 currency perspectives, our answer is a qualified "yes". Currency hedging was effective in reducing risk and generally improved medium to long-term Sharpe ratios, albeit at a small cost to average returns. It may not be the proverbial free lunch, but does appear a value meal from the risk-adjusted perspective that is most relevant in an asset allocation context. The most effective hedging strategy and the resultant benefits varied by investor domicile, the nature of the equity holdings, and over time. The benefits were strongest for defensive (low-volatility, non-cyclical) equity portfolios for investors from safe-haven currency zones, and least pronounced for cyclical equities held by investors using pro-cyclical currencies. For example, contrary to common belief, Australian and Canadian investors may yet gain from currency hedging, at least for some global equity strategies. Particularly since the Global Financial Crisis, being smart about how much of a portfolio's currency exposures to hedge has been a key to avoiding perverse impacts.

US investors have shown an increased appetite for currency-hedged international equities. ETF market leader Blackrock launched currency-hedged international equity ETFs in February 2014, joining existing offerings by WisdomTree and Deutsche Bank. Net inflows in 2013 into the WisdomTree Japan Hedged Equity Fund totaled $9.7 billion, second only to the SPDR S&P 500 ETF. Much of these flows were driven by tactical considerations, according to media reports[2]. These include "Abenomics" driving the yen down but export-driven Japanese equities up, as well as the prospect of normalization in the U.S. Federal Reserve policy strengthening the dollar. After these themes have played out, the question is whether structurally hedging currency risk benefits long-term global equity investors absent a directional view on exchange rates[3]. Based on a 35 year back-test of 3 smart beta strategies from 6 currency perspectives, we find that the answer is a qualified "yes". Currency hedging meaningfully reduces return volatility. It generally improved medium and long-term Sharpe ratios, albeit at a small cost to average

[1] Sanne de Boer is a senior research analyst at QS Investors. This paper has benefited greatly from useful comments and discussions with Daniel Lam, James Norman, Adam Petryk, and Alex Saunders. We thank Nicole Phan and Sarah Reifsteck for editing and formatting support.

[2] Fund flows sourced from ETF.com. For speculation about the reasons behind it, see Hougan (2013) in Financial Advisor Magazine, Reklaitis (2013) on MarketWatch.com, and Lau (2014) on reuters.com, among others. Aside from directional views on exchange rates, El-Erian (2014) in the Financial Times argues that currency instability may increase as countries' monetary policies diverge. Schwartz and Gannatti (2014) list arguments in favor of hedging.

[3] The question on the long-term benefits of currency hedging is in fact already being asked, for instance on Barrons.com (Conway, 2014). Their answer was no, based on observed long-term mean reversion of exchange rates, but this assumes short-term return volatility is irrelevant. The bear market of 2008 showed that few investors have the ability to simply sit out large drawdowns, for various reasons.

returns. Currency hedging may not be Perold and Schulman's proverbial free lunch, but does appear a value meal from a risk-adjusted perspective[4]. The latter is what matters most in an asset allocation context, allowing increased exposure to global equities while maintaining the same level of total risk.

Recent research suggests a notable exception to the risk-reduction benefits from currency hedging: investors whose domestic currency tends to strengthen as global equity markets rise[5]. This includes natural-resource exporting countries such as Canada, Australia, and certain Emerging Markets. Exchange rate movements provide a natural hedge for the return on international stocks for those investors, thus currency hedging could perversely even increase portfolio risk. This exception is usually identified based on the performance of capitalization-weighted global equity indices, just as smart beta alternatives have become increasingly popular. We investigate whether the benefits of currency hedging for global equities also depend on the nature of the underlying investment strategy, rather than investor domicile alone. Per our back-test, the answer is: most definitely. In particular, we identify the following key drivers of currency risk in global equity portfolios: the weight allocated to international equities, the return volatility of the underlying equity and currency holdings, and the interaction between those two. This interaction in turn depends on the cyclicality and origin of the equity holdings as well as the investor's domicile. We find the benefits of currency hedging were strongest for defensive (low-volatility, non-cyclical) equity portfolios for investors from safe-haven currency zones, and least pronounced for cyclical equities held by investors using pro-cyclical currencies. To highlight just one actionable insight: Australian and Canadian investors may yet benefit from hedging the currency risk of defensive global equity portfolios.

The outline of the remainder of this report is as follows. We first describe the three considered investment strategies and highlight differences in their holdings and historical performance. We then identify and illustrate four key determinants of currency risk in global equity portfolios. Next, we provide insight into what makes for effective (i.e., smart) currency hedge ratios, which vary by the nature of the equity holdings as well as investor domicile. We then present the impact of currency hedging on performance, including factor and theme based smart beta portfolios to broaden our scope, and conclude with thoughts on future work. In the appendix we have included a literature review, implementation details of the back-test, as well as some additional analysis results.

The appeal of smart beta investing

We analyzed the impact of currency hedging for three investment strategies: capitalization-weighting (CW) and equal-weighting (EW) of equities, as well as the minimum-volatility portfolio (MINVO)[6]. Each portfolio is the same regardless of investor domicile. We choose EW and MINVO to represent smart beta strategies: systematic approaches to investing that have gained traction as alternatives to traditional passive capitalization-weighted indices[7]. Portfolio construction for EW and MINVO allocated capital among country-sector indices such as "United States Utilities" and "Swiss Healthcare" rather than among individual stocks. These indices themselves are capitalization-weighted baskets of all stocks in the point-in-time Datastream Global Equity Index from that country and sector combination. De Boer et al. (2014) showed that such country-sector allocation as the basis for

[4] Perold and Schulman were early advocates of currency hedging for global equities as a "free lunch" in an eponymous influential 1988 paper in the Financial Analysts Journal.

[5] This effect is illustrated in Peterson LaBarge (2010) of Vanguard and Del Vecchio and Handley (2010) of JP Morgan, in addition to a number of academic papers reviewed in our appendix.

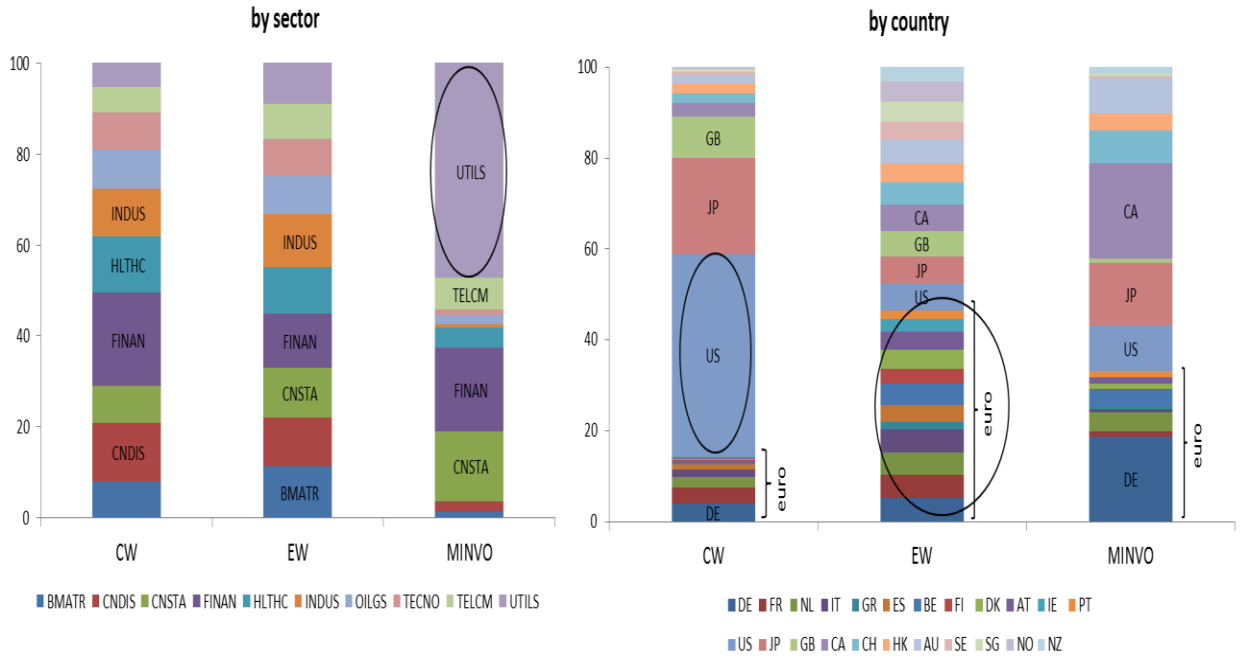
[6] For MINVO we construct the minimum-variance portfolio based on historical stock returns measured in their local currency. It is therefore the same portfolio regardless of investor domicile, just like CW and EW. Further details on portfolio construction are in Appendix B.

[7] There is no single definition of what constitutes smart beta. Defining characteristics typically include simple, transparent, systematic and low-cost exposure to suspected market risk premiums. We refer to a report by Towers Watson (2013) for further background on these strategies and their appeal.

minimum-volatility investing historically provided the same performance as individual stock selection, while providing liquidity benefits. Our back-test covered Developed Markets equities going back to 1979. We considered the perspective of investors from 6 different currency zones: the United States (US), Great Britain (GB), Germany (DE), Japan (JP), Australia (AU) and Canada (CA). Currency hedging was implemented through forward contracts. On a monthly basis between 0% and 100% of each currency exposure in the equity portfolio was hedged so as to minimize its predicted return volatility measured in the investor's domestic currency. Details are included in the appendix, together with a review of related literature.

Exhibit 1 illustrates differences in the historical holdings of the three considered strategies[8]. We note that the CW portfolio held a large weight in US stocks, as well as Japan and Great Britain. In contrast, the EW portfolio held a large weight in Eurozone stocks. The salient feature of the MINVO portfolio is its large weight in defensive sectors, particularly Utilities and Staples. **Exhibit 2** explains the appeal of the EW and MINVO smart beta alternatives to the CW index[9]. Both have historically outperformed CW on a risk-adjusted basis. The equal-weighted portfolio delivered the highest returns, albeit at the highest risk. The MINVO portfolio delivered higher returns than the CW, as well as the lowest overall risk.

Exhibit 1: AVERAGE PORTFOLIO WEIGHTS BY SECTOR AND CURRENCY ZONE (1979- 2013)

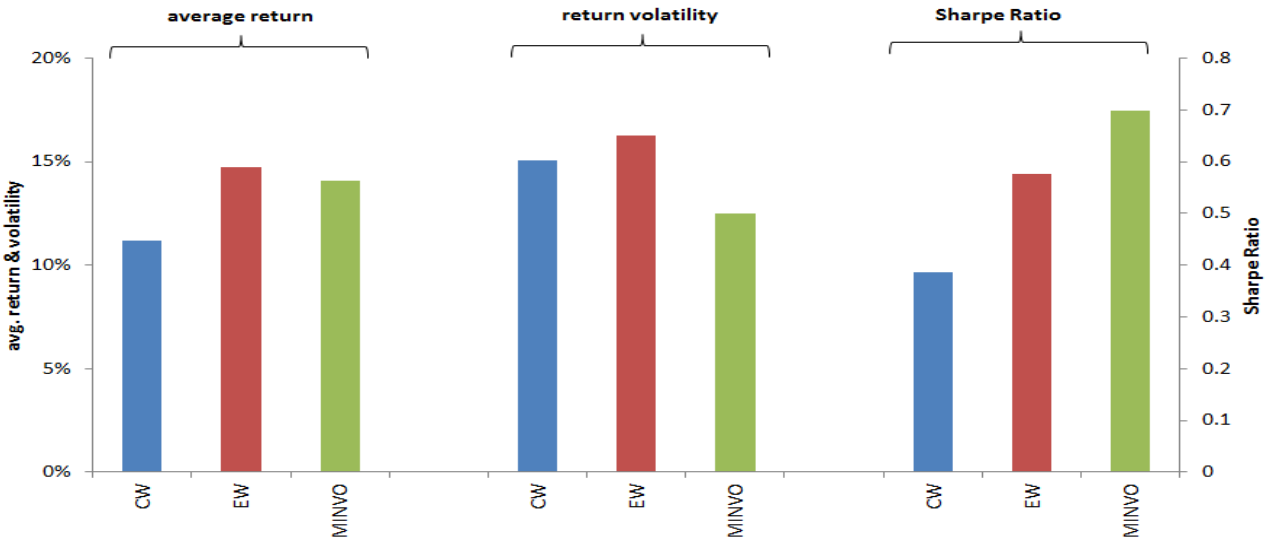


Source: QS Investors analysis, Datastream, Bloomberg, Global Financial data; monthly average holdings from January 1, 1979 to December 31, 2013

[8] We show historical average weights, but these remain representative of strategy holdings today. Eurozone is defined as all countries currently using the Euro, plus Denmark whose Krone is closely pegged.

[9] Results shown are from the USD perspective. Results from other currency perspectives were consistent and therefore not shown. The long-term performance metrics obscure multi-year periods of smart-beta strategies lagging the capitalization-weighted market. Identifying the drivers of this is beyond the scope of this analysis.

Exhibit 2: LONG-TERM PERFORMANCE COMPARISON OF SMART BETA STRATEGIES (1979-2013)



Source: QS Investors analysis, Datastream, Bloomberg, Global Financial Data; USD returns gross of fees and transaction costs of hypothetical investment strategies from January 1, 1979 to December 31, 2013, all metrics annualized

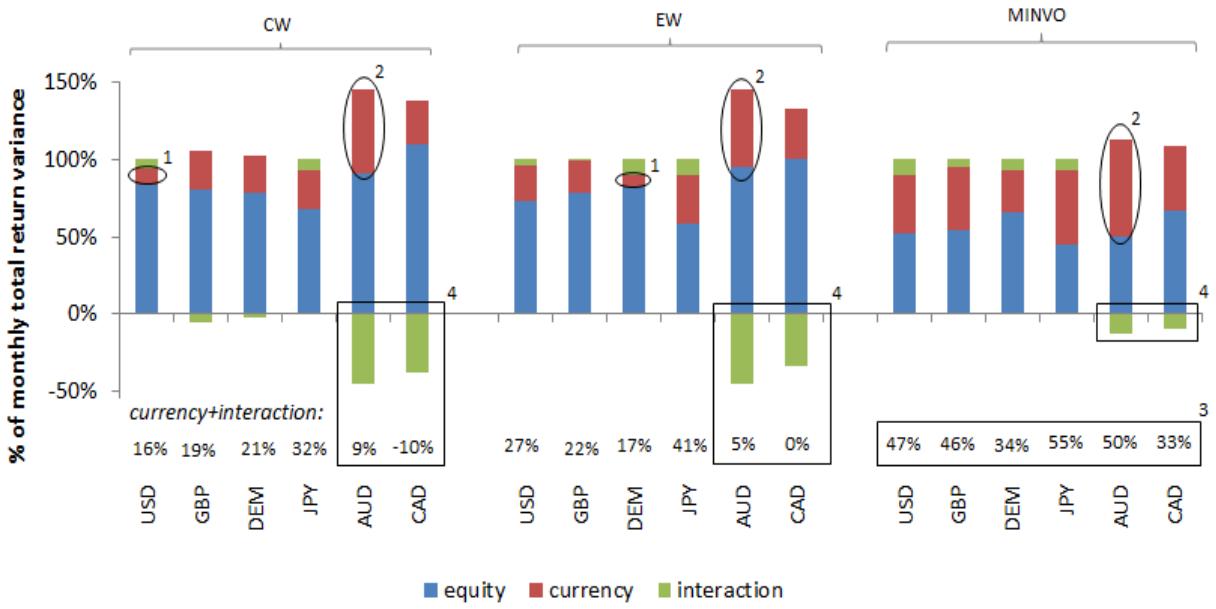
Determinants of currency risk in a global equity portfolio

Exhibit 3 breaks down the total historical return volatility of the considered investment strategies into its three contributors: the volatility of stock returns measured in their local currency, the fluctuations in the exchange rates of the investor's domestic currency, as well as the interaction between these two[10]. For each strategy, the differences in return volatility by investor domicile are driven by currency fluctuations, since the underlying equity portfolios are the same. We have identified four key determinants of the degree of currency risk in a global equity portfolio, which are listed below in boldface. Examples of these are marked on the chart. A theoretical argument is presented in the appendix; here we just aim to provide some intuition.

1. **Percent of holdings subject to currency risk:** The CW portfolio for a US investor and the EW portfolio for a German investor had little direct currency risk, since these investors' currency zones made up a large part of those respective portfolios.
2. **Volatility of FX rates:** The AUD has historically been a volatile currency, which resulted in the direct currency risk for Australian investors being relatively large.
3. **Return volatility of equity holdings:** The minimum-volatility portfolio by design invested in market segments with stable returns from their local-currency perspective, meaning that currency risk was a relatively larger component of total risk for this strategy.
4. **Correlation between equity returns and FX fluctuations:** The interaction between currency and equity returns for Australian and Canadian investors led to significant reductions in total risk for the CW and EW portfolios. As a result, the net impact of currency effects on these portfolios' risk was small or even negative. This effect was much smaller for the MINVO portfolio.

[10] This breakdown uses the well-known result on the variance of the sum of two random variables: VAR(X+Y) = VAR(X) + VAR(Y) + 2*STDEV(X)*STDEV(Y)*CORREL(X,Y), with X representing the local-currency equity returns, and Y representing the currency contributions to the portfolio's return measured in the investor's domestic currency. The interaction effect in Exhibit 3 refers to the correlation term.

Exhibit 3: BREAKDOWN OF PORTFOLIO RISK INTO EQUITY, CURRENCY, AND EQUITY/CURRENCY INTERACTION EFFECTS, BY INVESTOR DOMICILE (1979- 2013)



Source: QS Investors analysis, Datastream, Bloomberg, Global Financial data; using monthly returns from January 1, 1979 to December 31, 2013

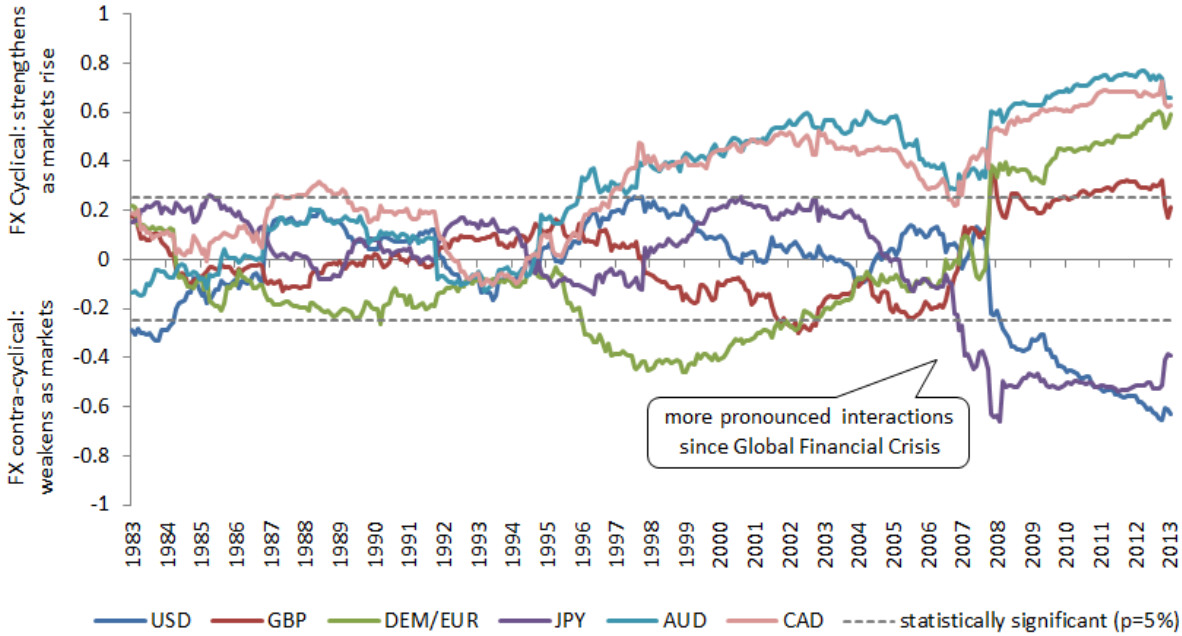
It is insightful to apply these criteria to a different asset class. Foreign investors in highly rated local-currency government bonds are fully exposed to currency risk; the FX volatility is high compared to other risks factors, while the pay-out in local-currency terms is substantially fixed and uncorrelated with FX rate movements. As a result, currency hedging is common practice for such investments (cf. Schmittmann, 2010.)

Exhibit 3 showed that the interaction between currency and equity returns is a large determinant of the degree of currency risk in a portfolio, and thus for the risk-reduction potential of currency hedging. To better understand this interaction, **Exhibit 4** shows the trailing correlation between currency and equity returns for the capitalization-weighted index, from the perspective of the 6 currencies we consider. Of note is that:

- The AUD and CAD have mostly been pro-cyclical, with the currency strengthening at the same time that global equity markets rose. Both Canada and Australia are large exporters of natural resources, meaning that demand for their currency rises at times that global economic growth drives the consumption thereof.
- The USD (most of time) and JPY (past decade) have been contra-cyclical, weakening as global markets rose and vice-versa. Both are perceived as safe-haven currencies in times of economic crisis.
- The DEM used to be contra-cyclical. The EUR, its successor, has been pro-cyclical since the Global Financial Crisis (2008) and even more so after the European Debt Crisis (2010), as has been the GBP. Investment in these currency zones will appear more appealing at times an upswing in global economic conditions might help them resolve the large problems with their financial institutions.

Exhibit 4: THE DYNAMIC INTERACTION BETWEEN EQUITY AND CURRENCY RETURNS, FOR THE CAPITALIZATION-WEIGHTED INDEX, BY INVESTOR CURRENCY

Trailing 60M correlation between currency appreciation and the global equity market (capitalization-weighted baskets of currencies and stocks, respectively, with stock returns measured in their local currency)



Source: QS Investors analysis, Datastream, Bloomberg, Global Financial data; using monthly returns from January 1, 1979 to December 31, 2013

This interaction affects the degree of currency risk in a global equity portfolio in the following way. Pro-cyclical currencies tend to appreciate at the same time as global equity markets rise, moderating the portfolio's gain measured from those currency perspectives. Concomitantly, pro-cyclical currencies tend to depreciate at the same time global equity markets retreated, dampening the portfolio's loss through gains on its currency exposures. Exhibit 3 captured how global investors from pro-cyclical currency zones like Canada and Australia benefitted from this natural hedging effect, albeit less so for non-cyclical equity portfolios like MINVO. In contrast, currency fluctuations will tend to exacerbate the impact of equity market movements for investors from contra-cyclical currency zones like the United States and Japan. This makes currency risk a bigger component of a portfolio's total risk for investors domiciled there.

Guidelines to effective currency hedging

We next illustrate how the nature of the currency exposures and equity holdings affect how much of the currency positions should be hedged in order to minimize a portfolio's total risk. We focus on currency hedging since the Global Financial Crisis, when the elevated interaction between currency and equity returns makes for stronger differentiation. As a starting point, **Exhibit 5** shows the average currency hedge ratio for several combinations of investor domicile and equity domicile for the EW portfolio. Clearly, the risk-minimizing policy is not to hedge or only partially hedge currency exposures for which the investor currency is cyclical versus the equity currency. When both currencies are cyclical or both are contra-cyclical, it is best to hedge most or all of the currency exposure.

Exhibit 5: AVERAGE CURRENCY HEDGE RATIO BY INVESTOR AND EQUITY DOMICILE, FOR EW PORTFOLIO

2008 - 2013		currency classification	average hedge ratio: EW portfolio investor domicile: defensive to cyclical JPY	USD	GBP	DEM	CAD	AUD	portfolio weight: EW portfolio
equity domicile: defensive to cyclical	AUD	cyclical	100%	100%	100%	100%	100%	N/A	4%
	CAD	cyclical	100%	100%	100%	100%	N/A	51%	4%
	EUR	cyclical	100%	100%	75%	N/A	16%	7%	52%
	GBP	cyclical	100%	100%	N/A	100%	61%	15%	4%
	USD	defensive	100%	N/A	8%	11%	0%	7%	4%
	JPY	defensive	N/A	0%	0%	0%	0%	0%	4%
	all	blend	100%	93%	65%	59%	30%	17%	

Source: QS Investors analysis, Datastream, Bloomberg, Global Financial data; average of semi-annual hedge ratios from January 1, 2008 to December 31, 2013

Exhibit 6 shows how the average hedge ratio differs for the CW portfolio from the EW portfolio. Comparison with Exhibit 5 shows that generally the hedge ratio is the same for each investor and equity domicile pair. However, the CW portfolio has more weight in equities denominated in contra-cyclical currencies, in particular the USD, while the EW portfolio has a large exposure to Eurozone stocks. We saw before that the former offer most non-US investors a natural hedging benefit, leading to lower hedge ratios. As a result, the last row of the table shows that all but Japan-domiciled investors would have hedged less of the CW than of the EW portfolio's currency risk. Japanese investors would have hedged 100% of the currency risk of both portfolios, reflecting the safe-haven nature of their currency.

Exhibit 7 shows how the average hedge ratio differs for the MINVO portfolio from that for the EW portfolio. Comparison with Exhibit 5 shows that both strategies have similar allocation to equities denominated in pro-cyclical currencies. However, generally the hedge ratio is higher for MINVO than for EW for the same investor and equity domicile pair, particularly when the investor currency is pro-cyclical or idiosyncratic versus the equity currency. The reason is that the MINVO equity holdings are predominantly in non-cyclical sectors like Utilities and Staples, and therefore benefit less from any natural hedging effect there may be. As a result, hedging it to a larger degree was the smart policy.

Exhibit 6: DIFFERENCE IN AVERAGE CURRENCY HEDGE RATIO BETWEEN CW AND EW PORTFOLIO BY INVESTOR AND EQUITY DOMICILE

2008 - 2013		currency classification	difference in average hedge ratio: CW vs. EW investor domicile: defensive to cyclical JPY	USD	GBP	DEM	CAD	AUD	difference in pf. wght: CW vs. EW
equity domicile: defensive to cyclical	AUD	cyclical	0%	0%	0%	0%	0%	N/A	-1%
	CAD	cyclical	0%	0%	0%	0%	N/A	49%	0%
	EUR	cyclical	0%	0%	16%	N/A	-2%	-3%	-34%
	GBP	cyclical	0%	0%	N/A	0%	-5%	17%	4%
	USD	defensive	0%	N/A	5%	4%	8%	5%	39%
	JPY	defensive	N/A	0%	0%	0%	0%	0%	6%
	all	blend	0%	-15%	-28%	-25%	-12%	-1%	

Source: QS Investors analysis, Datastream, Bloomberg, Global Financial data; average of semi-annual hedge ratios from January 1, 2008 to December 31, 2013

Exhibit 7: DIFFERENCE IN AVERAGE CURRENCY HEDGE RATIO BETWEEN MINVO AND EW PORTFOLIO, BY INVESTOR AND EQUITY DOMICILE

2008 - 2013		currency classification	difference in average hedge ratio: MINVO vs. EW investor domicile: defensive to cyclical						difference in pf. wght: MINVO vs. EW
			JPY	USD	GBP	DEM	CAD	AUD	
equity domicile: defensive to cyclical	AUD	cyclical	0%	0%	0%	0%	0%	N/A	12%
	CAD	cyclical	0%	0%	0%	0%	N/A	46%	36%
	EUR	cyclical	0%	0%	17%	N/A	35%	26%	-44%
	GBP	cyclical	0%	0%	N/A	0%	39%	85%	-4%
	USD	defensive	0%	N/A	61%	71%	33%	40%	4%
	JPY	defensive	N/A	0%	0%	0%	0%	0%	2%
	all	blend	0%	-4%	19%	27%	22%	45%	

Source: QS Investors analysis, Datastream, Bloomberg, Global Financial data; average of semi-annual hedge ratios from January 1, 2008 to December 31, 2013

In summary, the risk-minimizing currency hedge for any equity position varies by both the nature of the currency pair as well as that of the underlying stocks. The portfolio's overall hedge ratio reflects three characteristics that jointly determine the interaction between its currency and equity return contributions:

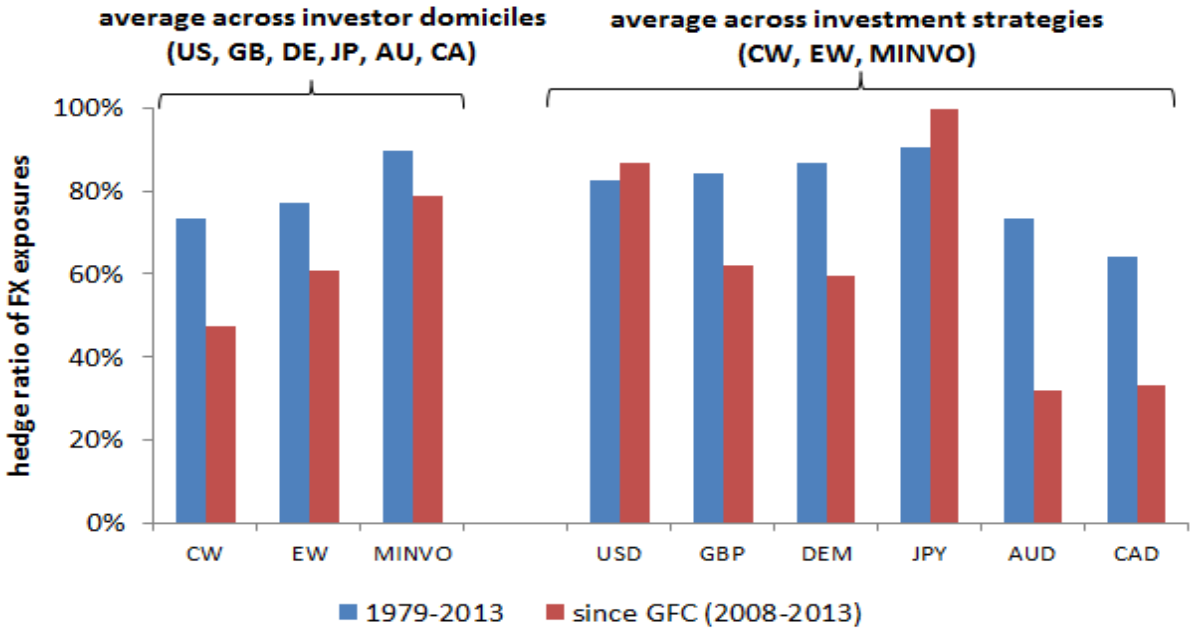
1. **The investor's domicile**; particularly the nature of its currency (pro-cyclical, idiosyncratic or contra-cyclical).
2. **The origins of the equity holdings;** particularly the predominant nature of their currencies (pro-cyclical, idiosyncratic or contra-cyclical).
3. **The predominant nature of the underlying equity holdings** (cyclical, core, or defensive).

None of these characteristics is necessarily static, as a deeper analysis of currency hedging for Canadian investors revealed (not shown). For instance, the CW portfolio return's lack of interaction with the CAD in the early 1990s was similar to the non-cyclical MINVO portfolio at that time. This was perhaps because its largest constituent country (the US) was going through its own specific set of fiscal problems and the aftermath of the First Gulf War. In comparison, the EW portfolio had the most cyclical equity holdings during that period, and thus would have benefitted least from currency hedging. In contrast, since the Global Financial Crisis the CW and EW portfolios' local-currency equity returns have both been similarly highly correlated with the CAD. As Exhibit 6 showed, it was the difference in currency exposures (contra-cyclical USD-CAD rather than the more idiosyncratic EUR-CAD) that made hedging much less beneficial for the CW portfolio over this period. We therefore recommend adjusting hedge ratios periodically using updated correlations to reflect changing market conditions.

To further illustrate this, **Exhibit 8** puts the period since the Global Financial Crisis in the perspective of the entire back-test period[11]. We note that the average hedge ratio increased a bit for US and Japanese investors but decreased significantly for British and German investors. It decreased the most for Australian and Canadian investors, for whom it was lower to begin with. This reflects the stronger interactions between currency and equity returns noted in Exhibit 4, as well as the GBP and EUR having joined the AUD and CAD as pro-cyclical currencies. We also note that the average smart hedge ratio decreased for all investment strategies. Since 4 out of the 6 considered investor currencies were pro-cyclical, this reflects an increased benefit from natural hedging effects, though least so for defensive equities.

[11] The results for 1979-2013 were very similar to the results for the non-overlapping "pre-2008" period.

Exhibit 8: COMPARISON OF CURRENCY HEDGE RATIOS FOR GLOBAL FINANCIAL CRISIS AND ENTIRE BACK-TEST PERIOD, AVERAGE ACROSS STRATEGIES AND INVESTOR DOMICILES



Source: QS Investors analysis, Datastream, Bloomberg, Global Financial data; semi-annual hedge ratios from January 1, 1979 (2008) to December 31, 2013

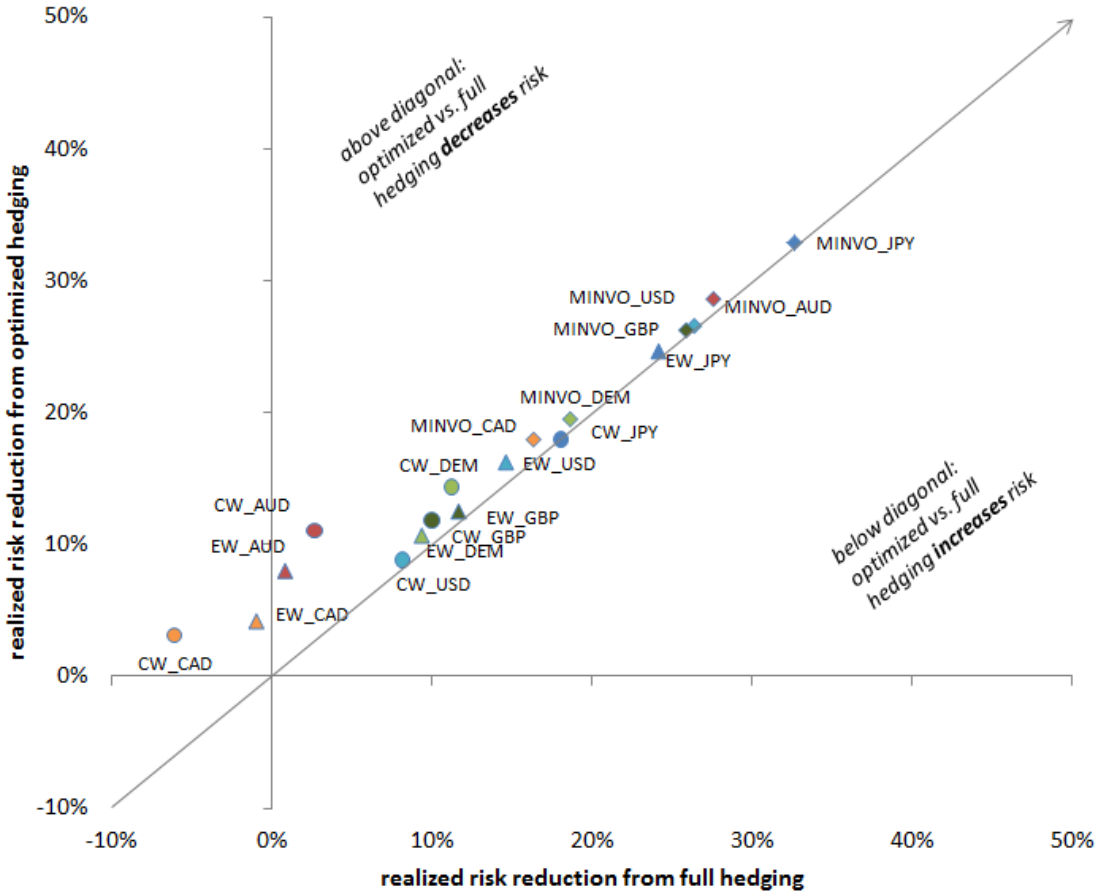
The performance impact of currency hedging

We next turn to the long-term performance impact of currency hedging for the considered investment strategies. Though we have assumed the hedges are put on to achieve maximum risk reduction, what truly matters in an asset allocation context is the impact on risk-adjusted return[12]. We use the Sharpe Ratio for that comparison.

We have coined the term "smart hedging" to contrast the use of optimization with simply hedging 100% of a portfolio's currency exposures. **Exhibit 9** compares the risk-reduction benefits. Smart currency hedging uniformly reduced the return volatility, as intended. The risk reductions are economically meaningful, particularly for the MINVO portfolio. The impact was smallest for Canadian investors in the CW or EW portfolio. For those investors, 100% hedging would have perversely raised risk by removing the natural hedging effect the CAD provides. We saw previously that interactions between currency and equity returns can be significant, persist over long periods of time, and are supported by sound economic rationales. It therefore makes sense to set the hedging strategy accordingly.

[12] To achieve maximum risk reduction in asset allocation, we could allocate 100% of the portfolio to risk-free cash.

Exhibit 9: REALIZED RISK REDUCTION FROM SMART VERSUS FULL CURRENCY HEDGING, BY PORTFOLIO AND INVESTOR DOMICILE (1979-2013, AS % OF UNHEDGED RETURN VOLATILITY)

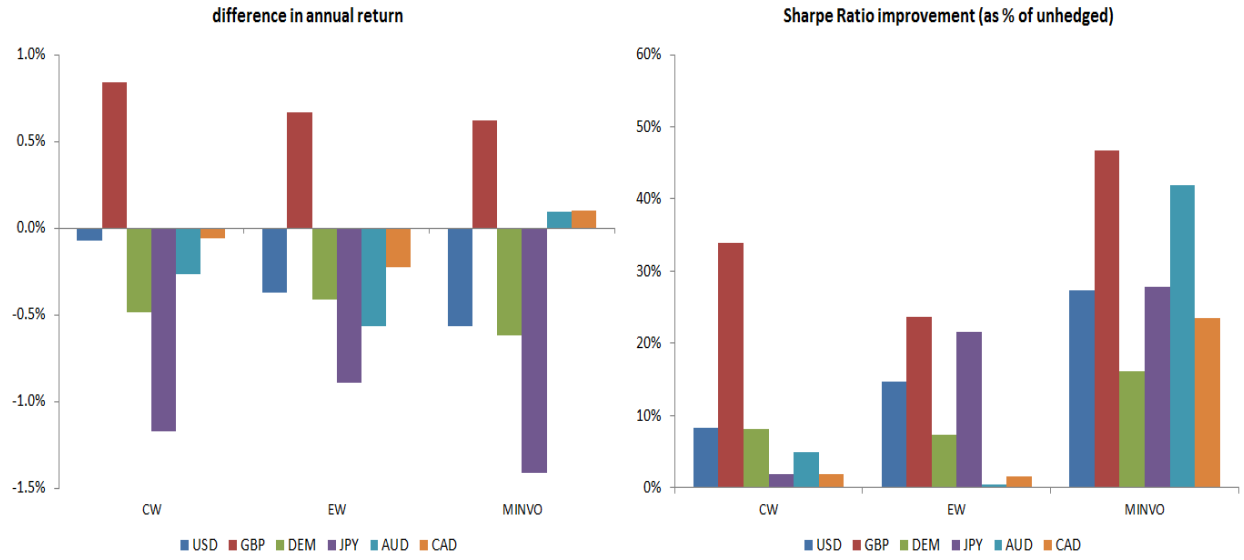


Source: QS Investors analysis, Datastream, Bloomberg, Global Financial data; using monthly returns from January 1, 1979 to December 31, 2013

Exhibit 10 shows that currency hedging reduced long-term average returns for nearly all portfolio and investor domicile combinations. The main exception is for British investors, who benefitted from the "carry trade" embedded in their currency hedging[13]. Exhibit 10 also shows that the long-term Sharpe Ratio impact was positive for all considered strategies and investor domiciles, without exception. The impact was generally largest for the MINVO strategy, which we know has relatively high currency risk compared to equity risk. It was generally lowest for Canadian investors, for whom we have seen that currency and equity interaction effects largely offset the impact of exchange rate volatility.

[13] Currency hedging is akin to lending money domestically and borrowing abroad, thereby earning or paying the interest rate differential. It is well known that when the spread is positive, like it was for British investors, this has historically not fully been offset by adverse currency movements. This is referred to as a "carry trade". In a separate test we noted that hedging the portfolio's currency exposures in full for Australian and Canadian investors would have raised their average return for the same reason. "Smart" (i.e., optimized) hedging left much of the positive-carry currency exposures unhedged, thereby maximizing the risk reduction benefit but foregoing the underlying carry trade.

Exhibit 10: LONG-TERM IMPACT OF SMART CURRENCY HEDGING ON AVERAGE RETURNS AND SHARPE RATIO, BY PORTFOLIO AND INVESTOR DOMICILE (1979-2013)



Source: QS Investors analysis, Datastream, Bloomberg, Global Financial data; using monthly returns from January 1, 1979 to December 31, 2013

Perold and Schulman (1988) famously described currency hedging as a "free lunch", based on the widely held belief that long-term exchange rate movements are mean-reverting[14]. If that is indeed the case and the direct cost (i.e., carry) of hedging were to be negligible, then this would be apt. However, our back-test suggests that hedging generally does not come free though has historically been priced cheaply relative to its risk-reduction benefits. Smart currency hedging might therefore yet be considered a "value meal" from the risk-adjusted perspective that is most relevant in asset allocation[15].

Few asset owners have investment horizons as long as the 35 years of our back-test. **Exhibit 11** shows the medium-term impact of currency hedging on risk-adjusted performance, splitting our back-test period into three (padded) decades. For most combinations of strategy, investor domicile and performance period, currency hedging improved the Sharpe Ratio. This was most often the case for MINVO investing and least often for the CW index, albeit still with a 67% hit rate. The median impact on MINVO was a substantial 32% increase in Sharpe Ratio, while for CW it was a still respectable 11% boost. For all considered periods, strategies and investor domiciles, we found the impact of currency hedging on realized volatility to be uniformly beneficial, while the impact on average returns was again mixed. To save space, we do not report these results in detail.

[14] Chen et al. (2013) argue strongly that historically exchange rates have in fact not been mean-reverting.

[15] At least, this was true for the specific period of our back-test for the considered investment strategies and investor domiciles.

Exhibit 11: MEDIUM-TERM IMPACT OF SMART CURRENCY HEDGING ON SHARPE RATIOS, BY PORTFOLIO AND INVESTOR DOMICILE

investment strategy →		CW		EW		MINVO	
"hit rate" (% no worse)→		67%		78%		100%	
period ↓	currency ↓	unhedged Sharpe Ratio	improvement from hedging (as % of unhedged)	unhedged Sharpe Ratio	improvement from hedging (as % of unhedged)	unhedged Sharpe Ratio	improvement from hedging (as % of unhedged)
1979 - 1990	USD	0.44	0.04 (+9%)	0.61	0.07 (+11%)	0.60	0.21 (+35%)
	GBP	0.29	0.17 (+59%)	0.48	0.21 (+44%)	0.48	0.33 (+69%)
	DEM	0.58	0 (0%)	0.80	0.05 (+6%)	0.94	0.04 (+4%)
	JPY	0.54	-0.01 (-2%)	0.69	0.13 (+19%)	0.81	0.12 (+15%)
	AUD	0.41	-0.02 (-5%)	0.60	-0.03 (-5%)	0.59	0.06 (+10%)
	CAD	0.32	0.08 (+25%)	0.51	0.08 (+16%)	0.49	0.23 (+47%)
1991-2001	USD	0.35	0.01 (+3%)	0.53	0.14 (+26%)	0.44	0.35 (+80%)
	GBP	0.37	0.04 (+11%)	0.55	0.17 (+31%)	0.48	0.35 (+73%)
	DEM	0.55	-0.05 (-9%)	0.73	0.08 (+11%)	0.80	0.13 (+16%)
	JPY	0.51	-0.1 (-20%)	0.63	0.13 (+21%)	0.57	0.3 (+53%)
	AUD	0.58	-0.16 (-28%)	0.81	-0.03 (-4%)	0.62	0.2 (+32%)
	CAD	0.59	-0.13 (-22%)	0.79	-0.05 (-6%)	0.74	0.1 (+14%)
2002 - 2013	USD	0.37	0.05 (+14%)	0.59	0.04 (+7%)	1.03	0.09 (+9%)
	GBP	0.25	0.1 (+40%)	0.54	0.02 (+4%)	0.92	0.22 (+24%)
	DEM	0.13	0.18 (+138%)	0.47	0.04 (+9%)	0.80	0.28 (+35%)
	JPY	0.29	0.08 (+28%)	0.50	0.09 (+18%)	0.82	0.25 (+30%)
	AUD	-0.17	0.23 (+135%)	0.24	0.07 (+29%)	0.45	0.48 (+107%)
	CAD	0.17	0.05 (+29%)	0.49	-0.02 (-4%)	0.97	0.07 (+7%)
median (across periods, currencies)→		0.37	0.04 (+11%)	0.57	0.07 (+12%)	0.68	0.22 (+32%)

Source: QS Investors analysis, Datastream, Bloomberg, Global Financial data; returns gross of fees and transaction costs of hypothetical investment strategies from January 1 to December 31 of each year in the stated date range, all metrics annualized

Over shorter investment horizons, 5 years and below, we noticed that smart currency hedging almost always reduced risk. **Exhibit 12** illustrates that for the period following the Global Financial Crisis. The impact was again lowest for cyclical equity portfolios and investors with pro-cyclical currencies[16]. Comparison with Exhibit 9 shows how the recent years have been different from the overall back-test period:

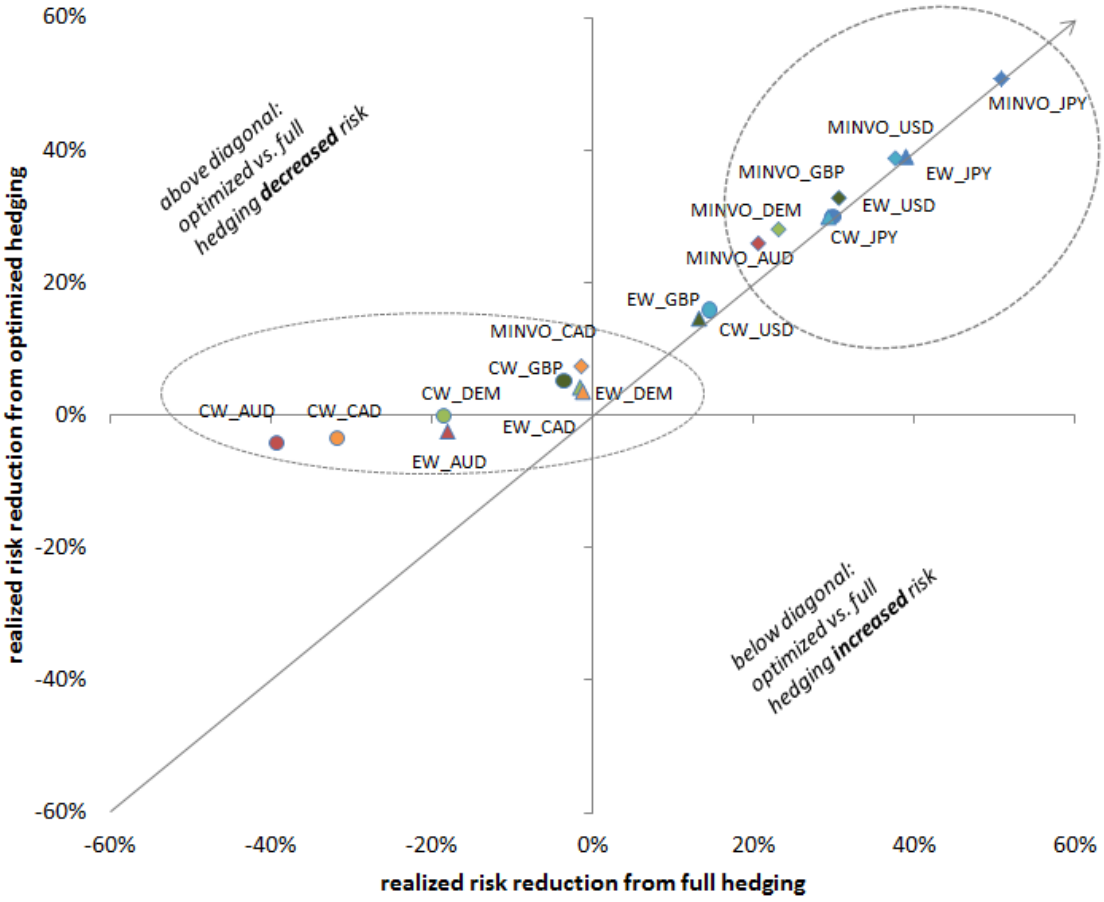
1. The overall risk-reduction benefit of currency hedging remained roughly unchanged. It was generally higher for the MINVO strategy and for investors using contra-cyclical currencies (USD, JPY), but lower for investors using pro-cyclical currencies, particularly for the CW and EW strategies.
2. However, the safe-haven DEM turned into the pro-cyclical EUR, while GBP also joined the AUD and CAD as pro-cyclical currencies. Therefore, the risk-reduction benefit for German and British investors in cyclical equities was lower recently than it has been in the past.
3. The negative impact of potentially "getting it wrong" by naively hedging 100% of a portfolio's currency exposures has grown tremendously. For instance, for an Australian investor in the capitalization-weighted index, full hedging would have nearly doubled her return volatility over this period.

The impact on the Sharpe Ratio over shorter investment horizons strongly depended on the investor's currency movement. For instance, **Exhibit 13** shows the impact of currency hedging was generally negative following the

[16] We note that even "smart" hedging had a slightly negative impact on total risk for Australian and Canadian investors in the CW portfolio, for whom 0% hedging would have been better than a calibrated "near 0%". This hints at the potential benefit of judicious use of the model output.

Global Financial Crisis for German, British and Canadian investors, whose currency weakened. It was positive for US and Japanese investors, whose currency strengthened. This example shows that when an investor has a strong directional view on his or her currency weakening in the near term, currency hedging may not be appealing.

Exhibit 12: COMPARISON OF REALIZED RISK REDUCTION FROM SMART VERSUS FULL CURRENCY HEDGING, BY PORTFOLIO AND INVESTOR DOMICILE (SINCE ONSET OF GLOBAL FINANCIAL CRISIS, AS % OF UNHEDGED RETURN VOLATILITY)

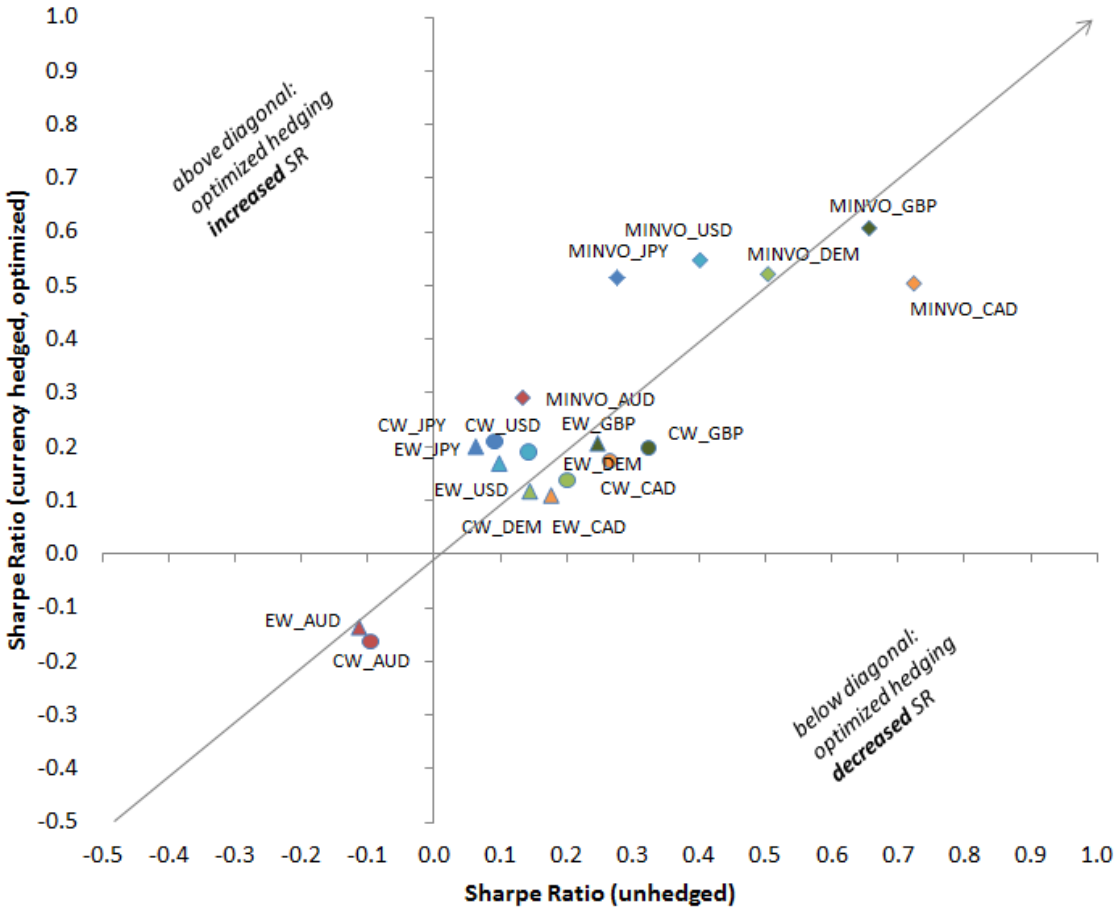


Source: QS Investors analysis, Datastream, Bloomberg, Global Financial data; using monthly returns from January 1, 2008 to December 31, 2013

Extension: factor investing and theme portfolios

In the above, we analyzed the historical performance of two smart beta strategies (EW and MINVO) in some depth so as to gain insight into what determines the potential benefits of currency hedging for global equities as well as the most effective hedging strategies. However, the smart beta moniker covers a much broader range of systematic strategies, including factor investing and theme portfolios. **Exhibit 14** shows the long-term impact of currency hedging for hypothetical Value and Momentum factor portfolios as well as Natural Resources and Commodity Exporters theme portfolios. Details on their portfolio construction are described in Appendix B. We note (top part of the exhibit) that for most of the additional smart beta strategies, the impact of currency hedging on the Sharpe Ratio over the analysis period was again beneficial. Exceptions include the Natural Resources portfolio for Australian and Canadian investors, and the Commodity Exporters portfolio for Australian investors. For these cases, we note (bottom part of the exhibit) how aggregate currency effects already provided a

Exhibit 13: SHORT-TERM IMPACT OF SMART CURRENCY HEDGING SINCE ONSET OF GLOBAL FINANCIAL CRISIS ON SHARPE RATIOS, BY PORTFOLIO AND INVESTOR DOMICILE



Source: QS Investors analysis, Datastream, Bloomberg, Global Financial data; using monthly returns from January 1, 2008 to December 31, 2013

natural hedge for the portfolio. Attempting to strengthen this effect by selectively hedging currency exposures led to a small risk reduction at a modest cost to average returns (middle part of the exhibit), resulting in a slightly negative to flat impact on the risk-adjusted return. The other exception is Japanese investors in the Natural Resources portfolio. We note how the average return impact of hedging for Japanese investors in both cyclical theme portfolios was meaningfully negative due to the embedded short carry trade. However, the degree of currency risk in the Commodity Exporters portfolio was generally larger than in the Natural Resources portfolio. This is due to the added pro-cyclicality of the commodity-exporting countries' currencies, which would not affect the volatility of US and Great Britain based natural-resources stocks for Japanese investors. This combined to make hedging beneficial for Japanese investors from a risk-adjusted perspective for the Commodity Exporters portfolio (Sharpe Ratio up 15%) but slightly detrimental for the Natural Resources portfolio (down 2%).

These findings suggest the following caveats to our earlier findings:

- Currency hedging may not be beneficial from a risk-adjusted return perspective when it "pushes the envelope" in reducing the currency risk of a portfolio that already has little of it. The potential for risk reduction may be limited relative to the possibly negative impact on average returns.

- The "cost" of the hedges matters. When hedging implies a large negative carry trade exposure while the potential risk reduction benefits are modest, it may not be worthwhile. This trade-off may have to be examined on a case by case basis when negative hedge carry is a clear concern, for instance for Emerging Market equities held by US investors.

Exhibit 14: UNDERSTANDING THE LONG-TERM IMPACT OF CURRENCY HEDGING ON SELECT FACTOR AND THEME PORTFOLIOS (1979 – 2013)

Sharpe Ratio improvement from hedging (as % of unhedged, by investor domicile and strategy)						
Strategy	**USD**	**GBP**	**DEM**	**JPY**	**AUD**	**CAD**
Value	12%	34%	10%	9%	6%	5%
Momentum	14%	27%	7%	7%	13%	6%
Commodity Exporters	20%	17%	11%	14%	-4%	9%
Natural Resources	7%	23%	2%	-2%	0%	-2%
Difference in annual return (hedged vs. unhedged, by investor domicile and strategy)						
Strategy	**USD**	**GBP**	**DEM**	**JPY**	**AUD**	**CAD**
Value	0.11%	1.09%	-0.22%	-0.71%	-0.09%	0.18%
Momentum	0.14%	0.99%	-0.42%	-0.98%	0.00%	0.08%
Commodity Exporters	-0.42%	-0.26%	-0.95%	-1.65%	-0.37%	0.11%
Natural Resources	-0.18%	0.63%	-0.55%	-1.30%	-0.29%	-0.19%
Currency contribution to risk (as % of unhedged portfolio total return volatility, by investor domicile and strategy)						
Strategy	**USD**	**GBP**	**DEM**	**JPY**	**AUD**	**CAD**
Value	14%	15%	31%	14%	-3%	-12%
Momentum	20%	18%	30%	17%	14%	-1%
Commodity Exporters	36%	35%	47%	31%	-1%	9%
Natural Resources	18%	13%	30%	12%	-4%	-12%

Source: QS Investors analysis, Datastream, Bloomberg, Global Financial Data; using monthly returns from January 1, 1979 to December 31, 2013

Conclusions and future work

We have analyzed the impact of structurally hedging currency risk on the historical performance of global equity portfolios. We found that:

1. For most investors in most time periods, hedging currency risk increased long-term Sharpe Ratios. Short-term, the direction of the investor's currency was the determining factor.
2. Naively hedging 100% of the portfolio's currency exposures could perversely increase risk by removing any natural hedging effect that might exist. It is important to be smart about setting the hedge ratios based on investor domicile as well as the investment strategy, particularly the cyclicality and origin of the equity holdings. This insight has become ever more relevant in the years following the Global Financial Crisis.
3. The underlying drivers of equity market and currency returns change through time, albeit slowly, and the hedging strategy should adapt accordingly.

Currency-hedged equity products should therefore make sense for most long-term investors even when agnostic on short-term exchange rate movements. In particular, we have identified opportunities for currency hedging of

defensive global equity strategies for Australian and Canadian investors, who might have been led to believe they could not benefit based on prior research reports.

Our analysis of this topic is still ongoing. Using hedged versions of global equity strategies in asset allocation should lead to modestly higher allocations due to their higher risk-adjusted return. We are still exploring the implications of this on the composition and return expectation of multi-asset portfolios. A possible extension of our work is to use currency overlay strategies on top of the baseline hedges of a global equity portfolio[17]. A carry overlay will in essence remove expensive hedges. Similarly, a momentum overlay will restore the portfolio's exposure to strengthening currencies. This might ameliorate the observed negative short-term performance impact of hedging when the investor's currency weakens.

Appendix A: Literature review

Traditionally there have been three schools of thought on currency hedging for global equities:

- Perold and Schulman (1988) advocate for full hedging. They argue that currency returns have zero expectation; therefore the reduction in the portfolio's short-term return volatility that results from hedging is a "free lunch".
- Froot (1993) argued that over the long term exchange rates are mean-reverting, removing the need to hedge currency risk for long-term investors, and found that such hedging historically even increased long-horizon return volatility for British investors in US stocks.
- Gardner and Wuilloud (1995) suggest hedging half of the currency risk as a way to minimize regret, as exchange rate movements can be large but their direction is hard to predict. Half-hedging is also supported by Black's (1989) "uniform hedge ratio" of around 50%, derived theoretically under certain (highly restrictive) assumptions.

More recently attention has shifted to how interactions between exchange rate fluctuations and equity markets affect the risk-minimizing currency hedge ratio, though this idea itself dates at least as far back as Kritzman (1993). Michenaud and Solnik (2008) include a survey on the prevalence of currency hedging by global equity investors.

Empirical results by Chang (2009), Del Vecchio and Handley (2010), Peterson LaBarge (2010), and Campbell et al. (2010) all highlight that investors from countries with pro-cyclical (also known as high-beta) currencies like Australia and Canada benefit from a natural hedging effect and should leave all or most of the currency risk in their global equity portfolios unhedged. Walker (2008) and Cho et al. (2012) show the same for investors from Emerging Markets investing in Developed Markets equities. Walker also notes that currency hedging might yet reduce return volatility for investors from countries with high idiosyncratic risk such as Argentina and Venezuela (cf. the second of our four determinants of currency risk).

Schmittmann (2010) and Campbell et al. (2010) provide comprehensive empirical comparisons of the above approaches. Both show that full-hedging is mostly optimal for global fixed income investors, due to currency volatility being much higher than bond returns volatility and bond returns being mostly uncorrelated with currency returns (cf. determinants 3 and 4 in our list). They also show the superiority of hedge ratio optimization for global equities, a point further emphasized in Kinlaw and Kritzman (2009). Schmittmann refutes the horizon-effect in currency hedging reported in Froot, while Solnik (1993) debunks Black's idea of a universal hedge ratio of all of a portfolio's currency risk and argues each currency position might be hedged differently.

[17] Tactical hedging is explored in Hamza et al. (2007).

Campbell et al. (2010) illustrate the potential risk-reduction benefits of "over-hedging", which in effect takes a short position in certain currencies. For instance, a US-based investor with a small allocation to Australian stocks could reduce her portfolio's return volatility by selling forward a much larger amount of AUD. This currency trade would be profitable at times the AUD weakens. This has historically coincided with periods that the portfolio's equity holdings would perform poorly and thus could use the boost. Since over-hedging might not be consistent with typical global equity mandates, we have not considered it in our study.

Most studies on the benefits of currency hedging for global equities focus on capitalization-weighted global indices or an equal-weighted combination of select capitalization-weighted country indices. An exception is De Boer and Norman (2014), who show the strong benefits of full currency hedging for global low-volatility investing and its impact on the underlying equity holdings. With some exceptions, the focus of most published research on currency hedging is also on its risk-reduction benefits rather than the impact on average or risk-adjusted returns. Walker (2008) does note that currency hedging improves average returns for investors from Emerging Markets investing in Developed Markets equities as an implicit carry trade. Consistent with our results, Campbell et al. (2010) report a mostly positive impact on Sharpe Ratios. In sharp contrast, De Roon et al. (2013) report a highly negative impact on Sharpe Ratios. We suspect the reason is that the global equity portfolio they consider has an almost 30% weight to Australian and Canadian equities. Unlimited over-hedging to reduce the portfolio's return volatility, something our back-test disallowed, might further increase forward selling of the AUD and CAD. This implies a significant short position in the historically profitable carry trade, which explains why the resultant risk reduction falls short of covering the negative impact on average returns. This example does show that the cost side of hedging cannot be ignored.

Appendix B: Analysis details and data sources

The hypothetical investment strategies considered in this paper were implemented using capitalization-weighted country-sector equity indices rather than individual stock selection[18]. We used the country-sector indices constituted by Datastream using their 10 GICS-like sector definitions (e.g., "German Industrials"). The investable universe consisted of the point-in-time countries in the MSCI World Index except Malaysia, Luxembourg and Israel. The capitalization-weighted (CW) and equal-weighted (EW) portfolios were rebalanced monthly. The minimum-volatility portfolio (MINVO) was optimization-based, long-only, un-levered, and rebalanced semi-annually in May and November. Portfolio construction used the five-year trailing covariance matrix of weekly equity returns measured in local currency. Currency hedging was implemented using a monthly hedge of the principal investment based on the most recently calculated "smart" hedge ratios (see below). Forward currency prices were estimated through "Covered Interest Rate Parity" using 1-month LIBOR rates (e.g., Schmittmann [2010]). Further details on minimum-volatility portfolio construction as well as the data sources and estimation methods of historical forward exchange rates are in De Boer and Norman (2014), which studies the benefits of "naïve" currency hedging for minimum-volatility investing.

The hypothetical Natural Resources portfolio included all country-sector indices from the Materials and Energy sectors, weighted by their respective market capitalization and rebalanced on a monthly basis. The hypothetical Commodity-Exporters portfolio equally weighted between Norway's, Australia's and Canada's country indices, rebalanced on a monthly basis. Each country index included all country-sector indices from that country, weighted by their respective market capitalization. The hypothetical Value and Momentum portfolios were constructed as follows:

[18] We caution that actual investors are unable to directly invest in indices. Please refer to IMPORTANT INFORMATION footnote on page 1.

1. Each month, we calculate a Value metric (aggregate book-to-price) and Momentum metric (12 months trailing total return) for each country-sector index in the investable universe. We then cross-sectionally z-score the valuation and momentum levels to get standardized factor scores.

2. Each month, we rank the investable universe by the valuation score and select the top 33% (as measured by capitalization-weight in the investable universe) of country-sector indices to be included in the Value portfolio. The same is done to determine the constituents of the Momentum portfolio, using momentum scores.

3. Each of the selected country-sector indices' weight in the factor portfolios is calculated as the product of CW * score, where score is (1+z) if z>0, 1 / (1-z) if z < 0. Here z denotes its z-scored valuation or momentum score and CW denotes its capitalization-weight in the investable universe.

This process approximates how some index providers define their factor indices so as to provide liquid exposure.

The "smart" hedge ratios were updated semi-annually in May and November. For a given equity portfolio and investor domicile, we used optimization to determine the currency hedge ratios that minimized its total predicted risk. While the equity holdings do not vary by investor domicile, the optimized hedge ratios might. The cost or proceeds of the hedges (their "carry") was not used in this determination, though were captured in the reported performance metrics of our back-test. The optimization used the five-year trailing combined covariance matrix of weekly equity returns measured in local currency, as well as the investor's domestic currency's return relative to all other currencies represented in the investable universe. The hedge ratio for each currency exposure was constrained to be between 0% and 100% and allowed to vary across currencies. The hedge ratio for highly correlated currency exposures (annualized exchange rate volatility of less than 0.5%) was forced to zero so as to reduce the impact of pegged exchange rates on hedge ratios.

Appendix C: A simple model for currency risk in a global equity portfolio

We now present a simple mathematical model that we developed to identify the drivers of currency risk in a global equity portfolio. Consider some global equity portfolio with total return volatility σ_{tot}. In addition:

- Let w_c be the fraction of the portfolio invested in stocks bearing currency risk. Note that a currency union with the investor's domestic currency might exclude some international stocks from this sub-portfolio.
- Let σ_e be the volatility of equity returns when measured in stocks' local currency. This partially captures the risk reduction benefit of international diversification.
- Let σ_c be the volatility of the contribution of currency returns to the total return of the sub-portfolio bearing currency risk as measured in the investor's domestic currency. Keep in mind that the investor's currency weakening versus the held currencies when weighted by the portfolio's currency exposures would mean a positive contribution, while the investor's domestic currency strengthening would generally reduce her return on international stocks.
- Let $\rho_{e,c}$ be the correlation between the contribution of currency returns to the return of the currency-risk-bearing part of the portfolio when measured in the investor's domestic currency, and the overall portfolio's equity returns when measured in stocks' local currency.

Then it can be shown that the multiplier of the global equity portfolio's total risk resulting from currency risk equals:

$$\left(\frac{\sigma_{tot}}{\sigma_e}\right) = \sqrt{\left(\frac{w_c\sigma_c}{\sigma_e} + \rho_{e,c}\right)^2 + \left(1 - \rho_{e,c}{}^2\right)}$$

The relative contribution of currency risk to the portfolio's total risk is therefore:

1. Increasing in the percent of stocks held that are exposed to currency risk (w_c),
2. Increasing in the direct currency risk of the international holdings (σ_c), which is a holdings-weighted average of exchange rate volatilities.
3. Decreasing in the local-currency based equity volatility (σ_e).
4. Increasing in the correlation between currency contributions and (local-currency) equity contributions to the total portfolio return ($\rho_{e,c}$). This in turn is generally decreasing in the correlation between the investor's domestic currency's strength (how much of a foreign currency it buys) and the local-currency equity returns.

Note that the ratio above could possibly reach 0 when the interaction of exchange rate fluctuations and equity returns provide the perfect natural hedge.

While we developed this model mainly to provide intuition, it could conceivably be used to gauge the potential benefits of currency hedging using forward-looking predictions of its input parameters rather than a back-test.

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