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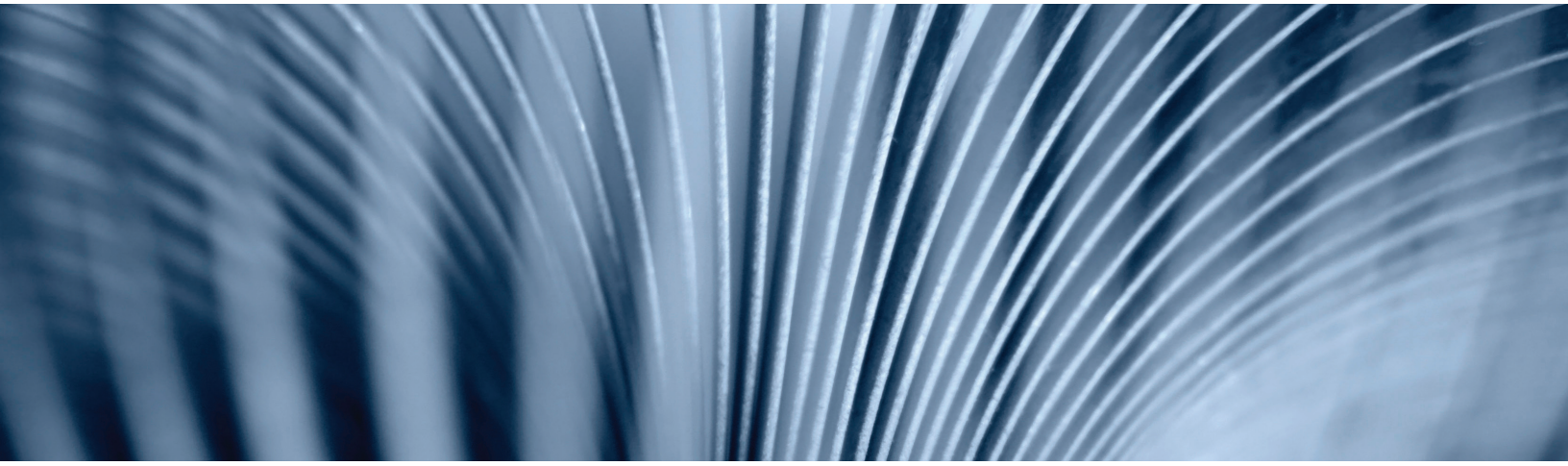

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Optimizing Currency Exposures under Solvency II

Solvency II imposes a solvency capital charge, generally at 25% under the Standard Formula, on foreign currency exposures. As a result, European insurers are incentivized to hedge fully, missing out on currencies' return and economic diversification potential. When we published our Dynamic Ideal Hedge Ratio (DIHR) methodology in 2016, we showed that it was possible to improve volatility-adjusted portfolio returns with a dynamic, opportunistic currency strategy that integrates currency hedging into whole-portfolio risk management. The DIHR provides a robust foundation for selecting a dynamic approach over a "passive" 100% hedge or the common, "least-regret" 50% hedge.

In this paper, we apply the DIHR to typical GBP- and EUR-based insurance-company portfolios. We adjust the methodology by "handicapping" the expected return of the portfolio's foreign currency exposures with a hurdle rate: the expected return to public equity adjusted for solvency capital charges. This hurdle reflects the opportunity cost associated with using solvency capital to fund foreign currency exposures rather than public equity investment. As such, it disincentivizes the removal of currency hedges unless the case for doing so is compelling from a return-on-capital or diversification perspective relative to taking public equity exposure. With this adjusted methodology we show that Solvency II-regulated insurers can improve capital-adjusted returns by taking currency risk opportunistically using the DIHR.

In the Appendix, we expand our study to show the results for different asset portfolios and different hurdle rates.

Executive Summary

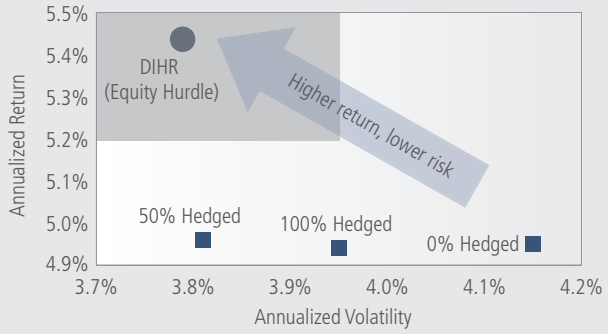
- The Solvency II Directive (2009/138/EC) imposes a specific solvency capital charge on currency mismatches between insurance companies' assets and liabilities. Most insurers choose to hedge the bulk of their foreign-currency exposures unless they hold a particularly strong view on currency valuations, but a 100% hedge will almost certainly fail to yield the best volatility-adjusted portfolio returns over time.

- In 2016 we introduced the concept of the Dynamic Ideal Hedge Ratio (DIHR) which showed that volatility-adjusted returns could be improved by taking foreign-currency exposures in a way that was opportunistic and completely integrated into whole-portfolio risk management. In this paper we apply the DIHR to two typical European insurance-company portfolios, one EUR-based and one GBP-based, adjusting the methodology by "handicapping" the expected return of the portfolio's foreign currency exposures, which is one of the DIHR's inputs. We assume an investor considering the DIHR would otherwise choose to allocate solvency capital to the public equity markets, and therefore we apply Neuberger Berman's long-term annual nominal return estimate for the MSCI World Index as a hurdle rate. We scale this return estimate to reflect the solvency capital ratio applied to this asset class. As such, the DIHR will not recommend the removal of currency hedges unless the case for doing so is compelling from a return-on-capital or diversification perspective, relative to taking public equity exposure.

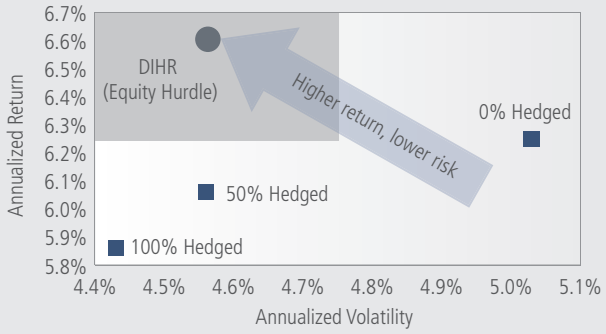
- We compare the results with three "benchmark" hedging strategies—100% hedged, 50% hedged and 0% hedged. For both insurance portfolios we show an improvement in volatility-adjusted return, as well as an improvement in volatility-adjusted return for each marginal unit of additional solvency capital required. In the Appendix we show results for different asset portfolios and different hurdle rates.

THE DIHR USES SOLVENCY CAPITAL EFFICIENTLY IN PURSUIT OF IMPROVED VOLATILITY-ADJUSTED RETURN

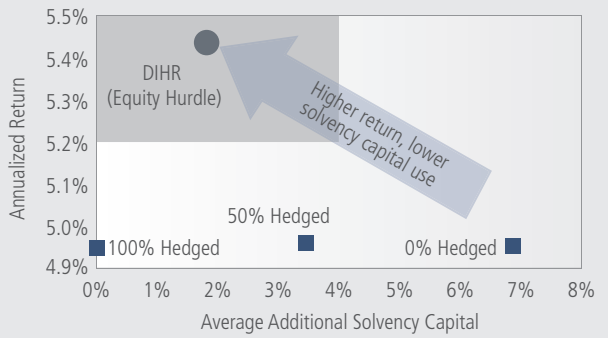
EUR-based insurance proxy portfolio investors



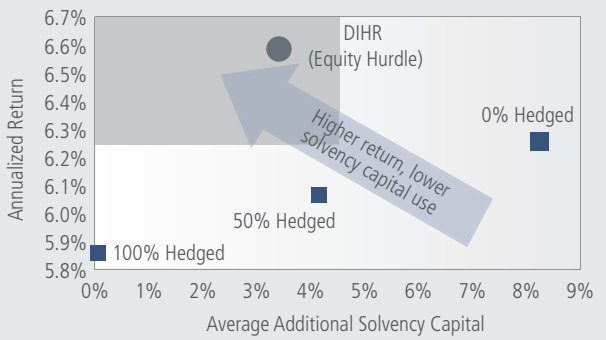
GBP-based insurance proxy portfolio investors



EUR-based insurance proxy portfolio investors



GBP-based insurance proxy portfolio investors



Source: Bloomberg, MSCI, Neuberger Berman Europe Limited calculations. Period under review is 31 January 2003 to 28 February 2018.

For the first time, the Solvency II Directive (2009/138/EC), passed in 2009 and in force since the beginning of 2016, imposed a specific solvency capital charge on currency mismatches between insurance companies' assets and liabilities, captured under the market-risk module of the Solvency Capital Ratio (SCR) calculation. The fifth and final Quantitative Impact Study (QIS5) specified that, for firms using the Standard Formula, the positive or negative impact on an insurer's total balance sheet should be calculated for a standard stress scenario of a 25% up or down move by each investment currency relative to the currency of the insurer's balance sheet.

In effect, the Standard Formula implies a capital charge of 25% for a foreign currency exposure, whether long or short. Some insurance companies have permission to calculate their SCRs with their own Internal Models, or with versions of the Standard Formula adapted to their own risk profiles, and more are expected to do so as Solvency II beds in.

While Internal Models can reduce the capital charge for foreign currency risk below that of the Standard Formula, insurance companies typically have still been reluctant to take these foreign-exchange exposures. Most insurers choose to hedge the bulk of their foreign-currency exposures unless they hold a particularly strong view on currency valuations.

Fully hedging does not always result in the most efficient portfolio, however. It may reduce risk at certain times, but incur very high hedging costs, for example. A 100% hedge will almost certainly fail to yield the best volatility-adjusted portfolio returns over time.

In this paper we show that a dynamic and opportunistic strategy for taking foreign-currency exposures can bring both return opportunity and diversification benefits at the whole-portfolio level—even when the Solvency II capital charges are taken into account. We believe the DIHR framework to be not only a more efficient, better integrated approach to hedging foreign currency exposures than traditional solutions, but also a potential source of additional return and diversification available to European insurers in a highly transparent and liquid market.

The methodology we describe works with the Standard Formula, but could be recalibrated to capture the more detailed parameters of an Internal Model—or indeed for many other kinds of investor constraints or requirements.

The Dynamic Ideal Hedge Ratio

In 2016 we introduced the concept of the Dynamic Ideal Hedge Ratio (DIHR). We had noticed that institutional investors typically respond to their portfolio's foreign currency exposures in one of five ways:

1. **Leaving them unhedged**
2. **Hedging them completely**
3. **Hedging 50% of the exposure**
4. **Setting a static hedge ratio between 0% and 100%, based on portfolio optimization**
5. **Deploying an active currency strategy to take or remove exposures based on market views**

Many of these investors assume that medium-term trends in currencies are unpredictable and that over the long term they revert to the mean. This belief that "it all comes out in the wash" leads them either to **hedge foreign-currency exposures completely**, or **not at all**, or at **50% as the "least regret" option.**

Others recognize that foreign-currency exposure could be a rewarded risk and act as a diversifier against other exposures in their investment portfolios. These investors have tended to set a **static hedge ratio between 0% and 100%** for each currency exposure, using mean-variance optimization based on historic returns and correlations with the investment portfolio assets; or go for **active management** of their currency exposures, usually with a tracking error limit relative to similar static hedge ratios. The first option has the advantage of embedding currency-hedging decisions into whole-portfolio risk management—but without taking into account dynamic investment opportunities or changing correlations. The second option is more dynamic—but it can introduce idiosyncratic manager and style risks.

Faced with these five typical approaches to currency management, our challenge with the DIHR was to show that whole-portfolio volatility-adjusted returns could be improved by taking foreign-currency exposures in a methodical, dynamic and opportunistic way based on their valuations, diversification benefits and hedging costs. The effect is to integrate currency risk management into whole-portfolio risk management.

THE DYNAMIC IDEAL HEDGE RATIO (DIHR): A REFRESHER

The Dynamic Ideal Hedge Ratio (DIHR) is a framework that makes foreign-currency management opportunistic, and integrates it into the whole-portfolio risk management process.

We use a Black-Litterman optimization approach to determine the hedge ratio that yields the best forward-looking risk-to-return ratio for the overall portfolio. In order to do this, the portfolio is deconstructed into three components, each with their own expected return and volatility characteristics: the portfolio's underlying assets; the portfolio's foreign currency exposures; and the costs of foreign-currency hedging.

In simple terms, the framework is more likely to recommend a **reduction** in the hedge ratio for foreign currencies when one or more of the following is true:

1. **THEY ARE UNDERVALUED:** They have deviated below purchasing power parity (PPP) fair value for an extended time.
2. **THEY ARE COSTLY TO HEDGE:** Their interest rates, as implied in short-dated forward markets, are high relative to the interest rate of the investor's base currency.
3. **THEY ARE DIVERSIFYING:** The rolling correlation between the foreign currencies and the investor's portfolio assets is low or negative.

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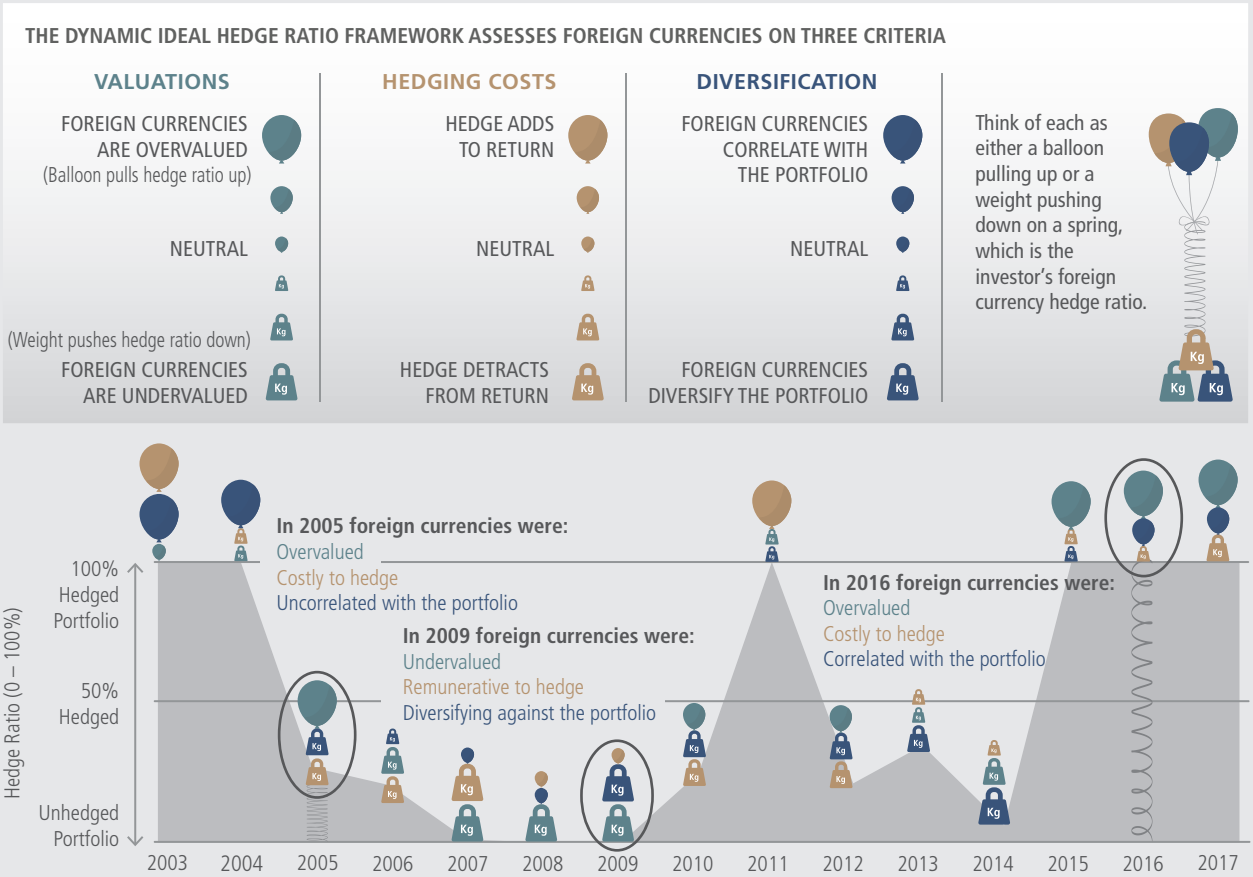
Likewise, the DIHR framework is more likely to recommend an **increase** in the hedge ratio when foreign currencies are overvalued, less costly or even remunerative to hedge, and/or not expected to diversify the portfolio. The net resulting decision to reduce or increase the hedge will depend on the relative strength of these three signals.



Source: Neuberger Berman. For illustrative purposes only.

TRADITIONAL HEDGING STRATEGIES HAVE SUBSTANTIAL DRAWBACKS

PROGRAM	DESCRIPTION	ADVANTAGES	COMMON JUSTIFICATIONS	OUR VIEW
UNHEDGED	Foreign currency exposures left intentionally unhedged.	Zero hedging costs incurred.	"Over the long term currency valuations revert to the mean—it all comes out in the wash." "Foreign currency risk is a diversifier against my underlying assets."	Valuations do mean-revert, but in the meantime foreign currencies are a source of uncompensated risk that can increase overall portfolio volatility dramatically. And why would an investor who believes in mean reversion not take advantage of large swings around fair value to hedge at attractive levels? Currency risk can amplify underlying-asset risk as well as diversify it, and even when it diversifies the effect is rarely strong enough to justify a completely unhedged exposure.
FULLY HEDGED ("PASSIVE")	All foreign currency exposures are hedged back to the investor's base currency.	Completely removes foreign currency risks.	"Foreign currency exposures are an unrewarded risk that adds volatility to my portfolio."	True, but not at all times. Hedging in full at all times can be very expensive, and foregoes potential outperformance and diversification benefits from intentional foreign currency exposures.
50% HEDGED	Only half of the foreign currency exposures are hedged.	Removes part of the foreign currency risk while maintaining some exposure to beneficial foreign currency moves.	"I cannot predict currency returns, and this is my 'least-regret' solution."	This could be a suitable solution for those without the resources or time to develop a proper strategy, but there is little economic justification for it.
STATIC HEDGE RATIO	A more sophisticated version of the solution above: A permanent, static hedge ratio is set between 0% and 100% of foreign currency exposure, usually based on mean-variance optimization using historical returns data from the currency markets and the underlying assets.	The optimal solution based on long-term historical currency-market performance and correlation trends.	"Once the appropriate policy benchmark has been determined there is little reason to review it."	Using historical return, volatility and correlation data to determine the static hedge ratio may not be optimal for the future—correlations in particular can be very unstable. A static hedge ratio does not adapt to changes in these relationships.
STATIC STRATEGIC HEDGE RATIO WITH ACTIVE MANAGEMENT	A permanent, static hedge ratio is set between 0% and 100% of foreign currency exposure, and that ratio is varied, within tracking-error limits, using a pure return-seeking currency strategy.	Adds flexibility to exploit pure alpha-generating opportunities.	"A static hedge ratio doesn't allow me to exploit potential excess-return opportunities in the currency markets but an active manager may."	True, but the active strategies deployed to vary the hedge ratio are pure return-seeking strategies that bear little relation to the investor's objectives or underlying risk exposures, and which generate substantial exposure to the currency manager's style biases and market views.

In our original paper, we applied the DIHR framework to USD-, EUR- JPY-, GBP-, AUD- and CAD-based investors in the MSCI World Index of global developed-market equities, between 2003 and 2015. Compared with a fully hedged, an unhedged and a 50% hedged investment, we showed improved volatility-adjusted returns and improved Sortino ratios for all six investors over time.[1]

The Dynamic Ideal Hedge Ratio for Solvency II-Regulated Investors

For European insurance investors, we make our tests specific to the Solvency II-regulated sector in two ways:

First, we create two bespoke portfolios, modelled on a EUR-based investor holding a proxy for a European insurance company investment portfolio, and a GBP-based investor holding a proxy for a UK insurance investment portfolio. This is important because one of the factors taken into account in the DIHR framework is the correlation between foreign currencies and the investor's asset portfolio.

Second, in our tests we adjust the foreign-currency expected-return input in the DIHR framework, effectively "handicapping" it by taking into account the opportunity cost associated with running unhedged foreign currency exposures. We are asking an investor to deploy solvency capital against active risk exposures, and therefore we need to show that the benefit to the portfolio of those exposures—based on the combination of expected currency appreciation and the expected cost or return of removing the hedge and its carry—would be greater than that gained from a realistic alternative deployment of the solvency capital.

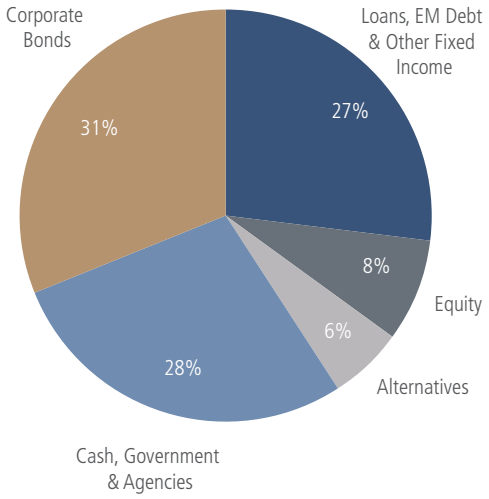
What did we choose as this opportunity-cost hurdle rate?

We assume that the investor who is considering employing the DIHR would otherwise choose to allocate solvency capital to public listed equity. To ensure we are comparing like-for-like we further assume that additional equity exposures would be implemented, unfunded, through the futures market.

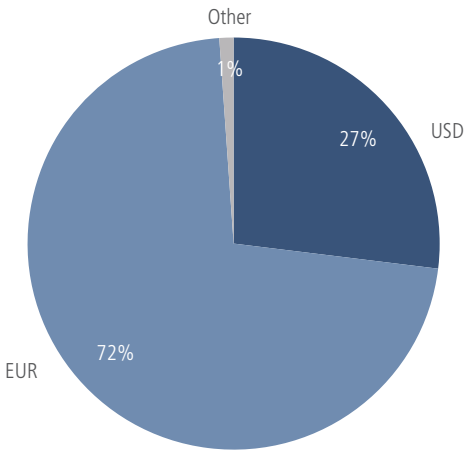
We therefore use Neuberger Berman's long-term annual nominal return estimate for the MSCI World Index as the basis for our hurdle rate. Because the Solvency II SCR for listed equity is 39%, that rate of expected return needs to be scaled down by a ratio of 25/39, or 64%, to reflect the fact that a smaller notional exposure to equity will require the same amount of capital as a larger exposure to foreign currencies.

WHAT IS IN OUR EUROPEAN INSURANCE COMPANY INVESTMENT PROXY PORTFOLIO?

European Insurance Proxy Portfolio: Asset Classes



European Insurance Proxy Portfolio: Currency Exposures

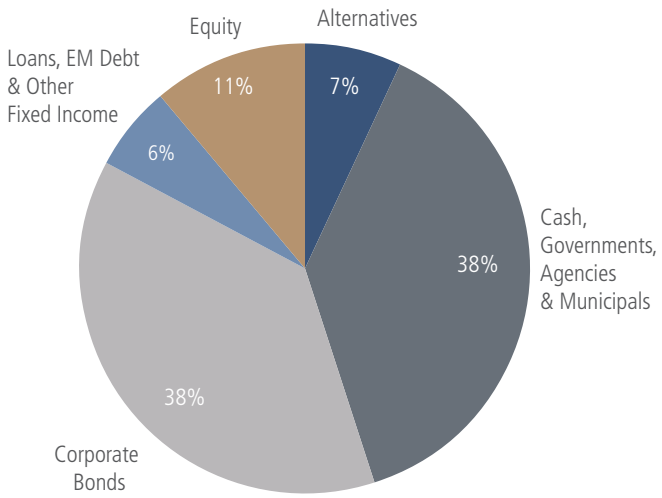


Source: Neuberger Berman estimates. Data as at 28 February 2018.

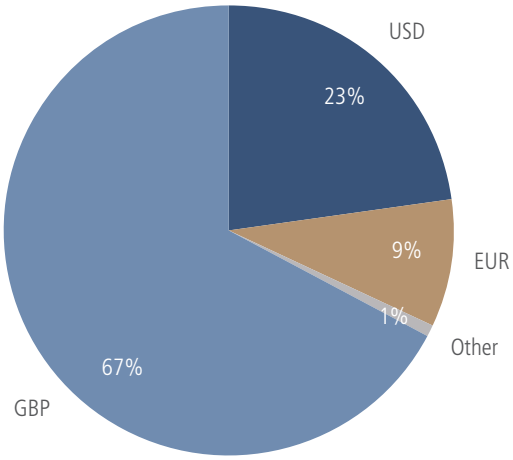
[1]Ugo Lancioni, Fredrik Repton, Nikola Petrovic, "Managing Currency Risk: An Opportunistic Framework for Institutional Portfolios". (April 2016), at https://www.nb.com/_layouts/www/transfer.aspx?URL=/insights/managing-currency-risk-an-opportunistic-framework-for-institutional-portfolios.aspx.

WHAT IS IN OUR UK INSURANCE COMPANY INVESTMENT PROXY PORTFOLIO?

UK Insurance Proxy Portfolio: Asset Classes



UK Insurance Proxy Portfolio: Currency Exposures



Source: Neuberger Berman estimates. Data as at 28 February 2018.

We believe that these are conservative assumptions. In particular, we have chosen to apply the standalone solvency capital charge of 25% for each foreign-currency exposure without taking into account any diversification benefits. In reality, given European insurers tend to have more exposure to equity risk than to foreign-currency risk, the true marginal impact on solvency capital of reducing the hedge ratio under the DIHR framework would likely be lower than for the "handicapped" strategies that we model here.[1]

With this Solvency II-adjusted, public equity expected return hurdle rate in place, our adjusted DIHR methodology will not recommend the removal of currency hedges unless the case for doing so is compelling from a return-on-capital or diversification perspective, relative to taking public equity exposure.

When we take into account both proxy portfolios, the equity hurdle rate and the three benchmark hedging strategies, this gives us eight different tests:

EUR-BASED INSURER	GBP-BASED INSURER
1. Fully hedged	1. Fully hedged
2. 50% hedged	2. 50% hedged
3. 0% hedged	3. 0% hedged
4. SII-adjusted DIHR hedged	4. SII-adjusted DIHR hedged

[1]The DIHR does consider the diversification benefits of foreign currency exposures as one of its inputs: lower correlations with the investor's asset portfolio are likely to lead to a recommendation to reduce the hedge ratio. However, this does not change the hurdle which another input, the foreign currency expected return, must exceed to recommend a reduction in the hedge ratio. This hurdle is determined by the solvency capital charge (on equity), which itself could potentially be lowered were it calculated taking foreign currency diversification benefits into account. For example, in the case of our European insurance company proxy portfolio, the marginal solvency capital charge for foreign-currency exposure can be as low as 8% if the portfolio starts out fully hedged. Even if we start with no hedge on the 28% of its assets that are non-EUR, the marginal charge for additional currency exposure is only 12%.

In all cases, we model the activity of the hedging strategies and the resulting portfolio returns over the period from January 2003 to February 2018.

We assume that the investor is using the Standard Formula to determine SCRs, but the tests and methodology could be recalibrated to capture the detailed parameters of an Internal Model.

There are essentially two questions we need to answer. First, is the Solvency II-adjusted version of the DIHR likely to lift an investor's currency hedges at all? And second, if it does, is the overall effect to improve the portfolio return and volatility-adjusted return achieved for each unit of solvency capital used?

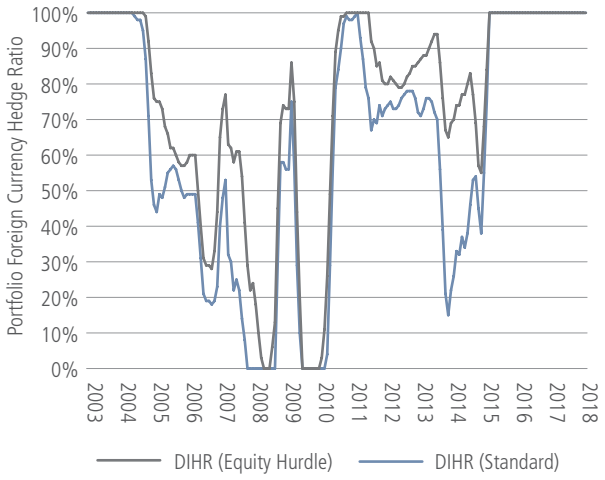
Does the SII-Adjusted DIHR Remove Currency Hedges?

Because we are imposing Solvency II-related handicaps onto the DIHR, it is reasonable to ask just how dynamic the resulting hedge ratio would be. Are the constraints so severe that the framework never, or rarely, lifts the investors' foreign-currency hedges?

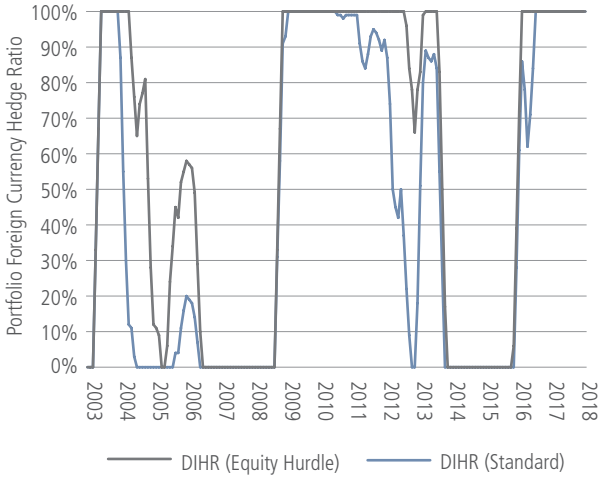
Between 2003 and 2018, both the standard and the Solvency II-adjusted DIHR frameworks allowed for the periodic lifting of hedges. The EUR-based insurer, using the standard DIHR framework, would have been less than fully hedged 70% of the time, over the period tested. Handicapping with the equity expected return hurdle, it would have been less than fully hedged 64% of the time. The GBP-based insurer, using the standard DIHR framework, would have been less than fully hedged 75% of the time. Handicapping with the equity hurdle, it would have been less than fully hedged 53% of the time. The full results are shown in figure 1.

FIGURE 1. SOLVENCY II-RELATED ADJUSTMENTS WOULD NOT HAVE CONSTRAINED THE DIHR FROM PERIODICALLY LIFTING HEDGES

Simulated Dynamic Ideal Hedge Ratio for a EUR-based investor in an insurance proxy portfolio—two DIHR frameworks



Simulated Dynamic Ideal Hedge Ratio for a GBP-based investor in an insurance proxy portfolio—two DIHR frameworks



Source: Bloomberg, Neuberger Berman Europe Limited calculations. Period under review is 31 January 2003 to 28 February 2018.

As expected, the strategy deploying the standard framework would have been less than fully hedged more often than the strategies deploying the Solvency II capital charge hurdles. Overall, however, these outputs strongly suggest that the Solvency II-adjusted DIHR framework identified benefits from periodically being unhedged.

Did Portfolio Results Improve?

We know, therefore, that the Solvency II-adjusted DIHR framework changes the foreign-currency exposures of the portfolios we tested. Did those changes result in improvements to returns, and volatility-adjusted returns, and did they do so with an efficient use of solvency capital?

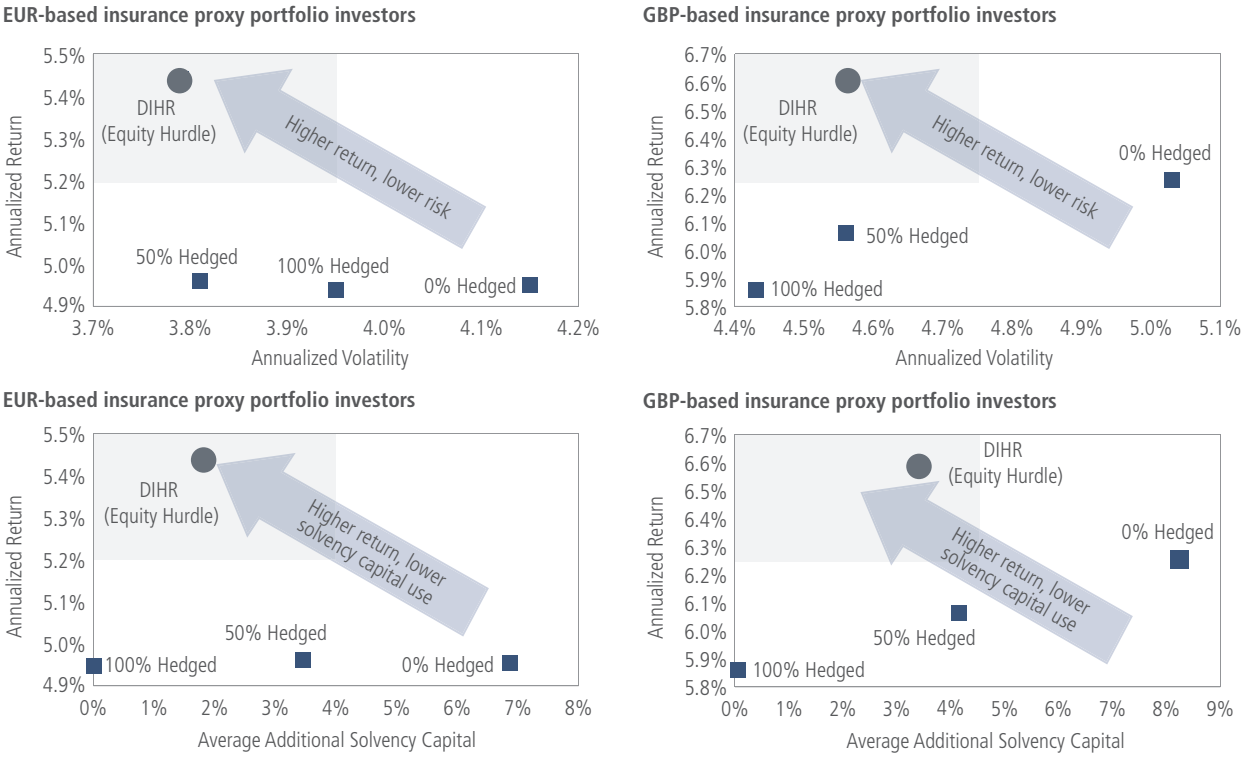
The results in figures 2 and 3 show that had the EUR-based insurer maintained a 100% hedge, it would have achieved a 4.94% annualized return with 3.95% volatility, a return-to-risk ratio of 1.25. Had it deployed the DIHR framework with the equity hurdle, the return would have risen to 5.44% and the volatility would have declined to 3.79%, a return-to-risk ratio of 1.44. This would have been achieved while generating just 1.81% of additional Solvency II capital requirements, on average.

Had the GBP-based insurer maintained a 100% hedge, it would have achieved a 5.86% annualized return with 4.43% volatility, a return-to-risk ratio of 1.32. Had it deployed the DIHR framework with the equity hurdle, the return would have risen to 6.58% and, while the volatility would have slightly increased to 4.57%, the return-to-risk ratio would have improved to 1.44. This would have generated 3.41% of additional Solvency II capital requirements, on average. For comparison, a static 0% or 50% hedged strategy would have delivered a lower return-to-risk ratio while generating 8.27% and 4.14% of additional solvency capital requirements, respectively.

Figure 2 shows how efficiently the DIHR framework uses the solvency capital it consumes. In both cases, the DIHR improves the volatility-adjusted return of the whole portfolio not only relative to the 100% hedged strategy, which uses no solvency capital, but also relative to the 50%-hedged or 0%-hedged strategies, which consume considerably more solvency capital. Figure 3 summarizes these results, as well as the improvement in pure return per unit of solvency capital used, in table form.

Deploying the DIHR frameworks with the Solvency II equity hurdle improved the return and the return-to-risk ratio for both of the insurance proxy portfolios, and generated no more than 3.41% of average additional solvency capital requirements over the period tested.

FIGURE 2. THE DIHR USES SOLVENCY CAPITAL EFFICIENTLY IN PURSUIT OF IMPROVED VOLATILITY-ADJUSTED RETURN



Source: Bloomberg, Neuberger Berman Europe Limited calculations. Period under review is 31 January 2003 to 28 February 2018.

FIGURE 3. SUMMARY RESULTS FOR INSURANCE PROXY PORTFOLIOS WITH EQUITY HURDLE

		Ann. return	Ann. volatility	Return / risk ratio	Average additional solvency capital	Return improvement (versus 100% hedged) per unit of average additional solvency capital	Return/risk ratio improvement (versus 100% hedged) per unit of average additional solvency capital
EUR-based insurance proxy portfolio investors	100% hedged	4.94%	3.95%	1.25	0.00%	**NA**	**NA**
	50% hedged	4.96%	3.81%	1.30	3.46%	**0.00**	**-0.82**
	0% hedged	4.95%	4.15%	1.19	6.92%	**0.00**	**-0.82**
	DIHR with equity future hurdle	5.44%	3.79%	1.44	1.81%	**0.28**	**10.18**
GBP-based insurance proxy portfolio investors	100% hedged	5.86%	4.43%	1.32	0.00%	**NA**	**NA**
	50% hedged	6.06%	4.56%	1.33	4.14%	**0.05**	**0.20**
	0% hedged	6.25%	5.03%	1.24	8.27%	**0.05**	**-0.98**
	DIHR with equity future hurdle	6.58%	4.57%	1.44	3.41%	**0.21**	**3.44**

Source: Bloomberg, Neuberger Berman calculations. Period under review is 31 January 2003 to 28 February 2018.

It is possible to incorporate the impact of opportunity cost into our analysis more fully. To do so, we take the returns of the Solvency II-adjusted DIHR-hedged portfolios and subtract a return stream equivalent to that which would be generated by taking the solvency capital used for foreign currency exposure and allocating it instead to the hurdle asset class (in this case, public equity). That return stream is scaled to match the foreign-currency solvency capital requirement on a monthly basis.

Despite the rigor of this test, for the EUR-based investor we found that the annualized return was improved by 0.31% against the 100%-hedged benchmark, while the return-to-risk ratio also increased, from 1.25 to 1.47. For the GBP-based investor the results were similar—an improvement in the annualised return by 0.21% p.a. against the 100% hedged benchmark, and increase in the return-to-risk ratio, from 1.32 to 1.51.

The DIHR framework with the equity hurdle rate beats the benchmark hedging strategies both on a total return basis and on a return-to-risk ratio basis, even when we include the opportunity cost of not being able to deploy the solvency capital used by the foreign currency exposures. This in turn confirms that the ex-ante hurdle rate that the adjusted DIHR framework imposes on foreign currency exposures is acting as intended, and that foreign currency risk can be a compensated risk even for Solvency II-regulated insurers.

In order to demonstrate the robustness of the results produced, we also tested the Solvency II-adjusted DIHR for EUR and GBP-based insurers allocated solely to the MSCI World Index hedged back to their respective domestic currencies. In addition, we applied a fixed income hurdle rate to the DIHR for our UK and European insurance company proxy portfolios to simulate a bond market return as the opportunity cost associated with taking foreign currency exposures.

The full results of these tests can be found in the Appendix. In every case, we found that deploying the Solvency II-adjusted DIHR frameworks improved both the portfolio return and the portfolio return-to-risk ratio while consuming low levels of additional capital.

Conclusion: An Integrated and Opportunistic Currency Hedging Framework

Institutional investors worldwide are implementing increasingly globally diversified portfolios at a time of big trends and heightened volatility in currency markets. In addition, suppressed expected returns in most traditional asset classes are pushing investors to consider alternatives, often in asset classes that introduce additional credit or liquidity risk. A combination of these three factors is causing a rethink of currency hedging policies and triggering a renewed interest in liquid currency solutions.

In our view the traditional approaches are unlikely to meet investors' requirements efficiently. Being fully hedged removes foreign currency risk, but the cost can sometimes be detrimental to performance. Static hedging policies based on historical optimizations tend to fail as market conditions change over time. Active hedging tries to correct for this and in some cases value is added in the form of pure alpha—but these approaches are rarely managed in the context of the broader asset portfolio, or with investor constraints such as Solvency II accounted for explicitly. For this reason they often fail to improve overall risk-adjusted returns.

The DIHR both integrates foreign currency risk management with the overall portfolio construction process and makes it dynamic and opportunistic. In doing so, it creates the opportunity to deploy currency hedging as a tool to help improve overall portfolio risk-adjusted returns over time.

Moreover, in this paper we have shown that the DIHR can be simply and transparently adapted to take account of specific investor requirements; in this instance, we have adapted the framework to a model of the constraints of Solvency II-regulated insurance entities. Our results, obtained using stylized insurance company asset allocations and conservative assumptions, show that, over the test period, DIHR would have substantially improved whole-portfolio outcomes.

Our view is that these positive results reflect the robustness of the framework itself, and that gives us confidence that similar improvements could be delivered for the asset allocation and capital calculation methodologies of specific insurance investors—or indeed for investors with many other kinds of constraints or requirements.

APPENDIX

In our paper we show that the Dynamic Ideal Hedge Ratio (DIHR) framework would have identified opportunities to remove foreign currency hedges for typical EUR- and GBP-based insurance company portfolios, even when handicapped with an equity expected return hurdle rate to take account of the opportunity cost, under Solvency II, of using solvency capital to take foreign currency exposures. In doing so, it would have improved the volatility-adjusted return of the whole portfolio not only relative to a 100% hedged strategy, which uses no solvency capital, but also relative to a 50% hedged or 0% hedged strategy, which consume considerably more solvency capital.

In order to demonstrate the robustness of the results produced by employing the DIHR, we also ran our analysis under two further scenarios.

In our first scenario, we assumed that our EUR and GBP-based insurer balance sheets were comprised solely of allocations to the MSCI World Index, hedged back to their respective domestic currencies.

In our second scenario, we employed a fixed income hurdle rate in place of the equity hurdle rate, to simulate a bond market return as the opportunity cost associated with taking foreign currency exposures. In this case, the hurdle rate we used was the option-adjusted spread on a six-year, BB-rated corporate bond. The advantage of using this asset is that it also incurs a 25% capital charge under the Standard Formula, which makes the return on capital impact directly comparable to that of the foreign currency exposures introduced by the DIHR.

In total, this gives us tests for three different EUR-based strategies and three different GBP-based strategies, pursued by four different investors:

EUR-BASED INVESTORS	GBP-BASED INVESTORS
MSCI World Investors	MSCI World Investors
1. DIHR-hedged (equity hurdle)	1. DIHR-hedged (equity hurdle)
Insurance Proxy Portfolio Investors	Insurance Proxy Portfolio Investors
2. DIHR-hedged (bond hurdle)	2. DIHR-hedged (bond hurdle)
3. DIHR-hedged (equity hurdle) – shown in the main paper	3. DIHR-hedged (equity hurdle) – shown in the main paper

Once again, we benchmark these against the 0%, 50% and 100% hedged strategies for the MSCI World and insurance-proxy portfolios in the two base currencies. In all cases, we model the activity of the hedging strategies and the resulting portfolio returns over the period from January 2003 to February 2018.

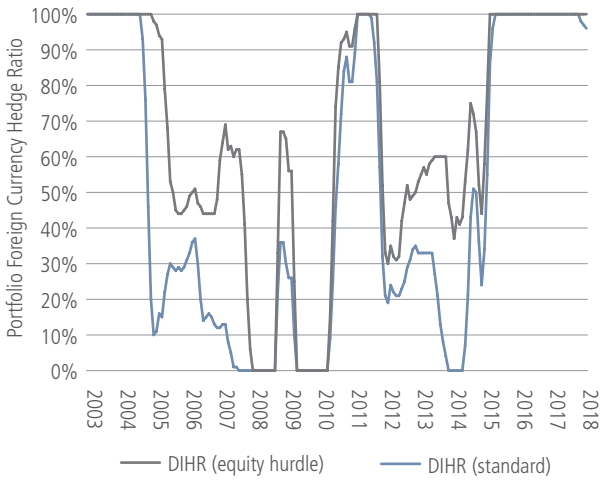
MSCI World Index Portfolios with Equity Hurdle: Does the DIHR Remove Currency Hedges?

Yes. Between 2003 and 2018, both the standard DIHR and the DIHR framework handicapped with the Solvency II-adjusted, equity expected return hurdle rate allowed for the periodic lifting of hedges.

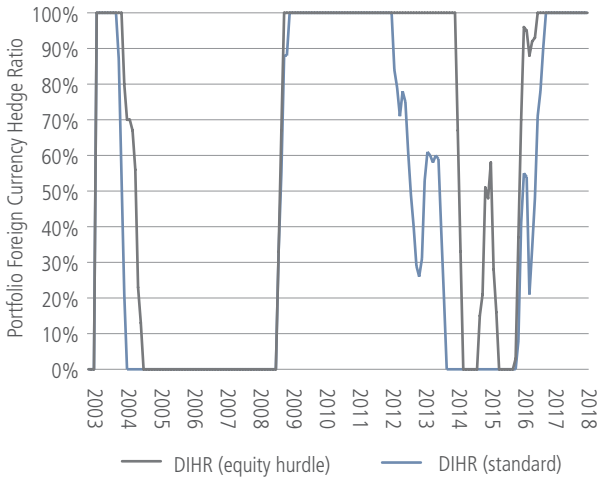
The EUR-based portfolio, handicapping with the equity hurdle, would have been less than fully hedged 62% of the time. The GBP-based portfolio, handicapping with the equity hurdle, would have been less than fully hedged 50% of the time. Under the standard DIHR framework, they would have been less than fully hedged 69% and 66% of the time, respectively.

FIGURE 4. SOLVENCY II-RELATED ADJUSTMENTS WOULD NOT HAVE CONSTRAINED THE DIHR FROM PERIODICALLY LIFTING HEDGES

Simulated Dynamic Ideal Hedge Ratio for a EUR-based investor in the MSCI World Index—two DIHR frameworks



Simulated Dynamic Ideal Hedge Ratio for a GBP-based investor in the MSCI World Index—two DIHR frameworks



Source: Bloomberg, Neuberger Berman Europe Limited calculations. Period under review is 31 January 2003 to 28 February 2018.

MSCI World Index Portfolios with Equity Hurdle: Are Results Improved?

Yes. Had the GBP-based MSCI World investor maintained a 100% hedge, it would have achieved a 6.88% annualized return with 12.86% volatility, a return-to-risk ratio of 0.54. Had it deployed the DIHR framework with the equity hurdle, the return would have risen to 8.96% and the volatility would have declined to 12.19%, a return-to-risk ratio of 0.73. This would have been achieved while generating 9.31% of additional Solvency II capital requirements, on average.

For comparison, a static 0% or 50% hedged strategy would have delivered a lower return-to-risk ratio while generating 22.61% and 11.31% of additional solvency capital requirements, respectively. Similar results for the EUR-based portfolio are shown in the summary table in figure 5.

FIGURE 5. SUMMARY RESULTS FOR MSCI WORLD INDEX PORTFOLIOS

		Ann. return	Ann. volatility	Return / risk ratio	Average additional solvency capital	Return improvement (versus 100% hedged) per unit of average additional solvency capital	Return/risk ratio improvement (versus 100% hedged) per unit of average additional solvency capital
EUR-based MSCI World investors	100% hedged	5.78%	12.87%	0.45	0.00%	**NA**	**NA**
	50% hedged	5.99%	11.91%	0.50	10.79%	**0.02**	**0.50**
	0% hedged	6.06%	11.96%	0.51	21.59%	**0.01**	**0.27**
	DIHR with equity future hurdle	7.15%	11.77%	0.61	7.32%	**0.19**	**2.17**
GBP-based MSCI World investors	100% hedged	6.88%	12.86%	0.54	0.00%	**NA**	**NA**
	50% hedged	7.62%	12.17%	0.63	11.31%	**0.07**	**0.80**
	0% hedged	8.22%	12.54%	0.66	22.61%	**0.06**	**0.53**
	DIHR with equity future hurdle	8.96%	12.19%	0.73	9.31%	**0.22**	**2.14**

Source: Bloomberg, Neuberger Berman calculations. Period under review is 31 January 2003 to 28 February 2018.

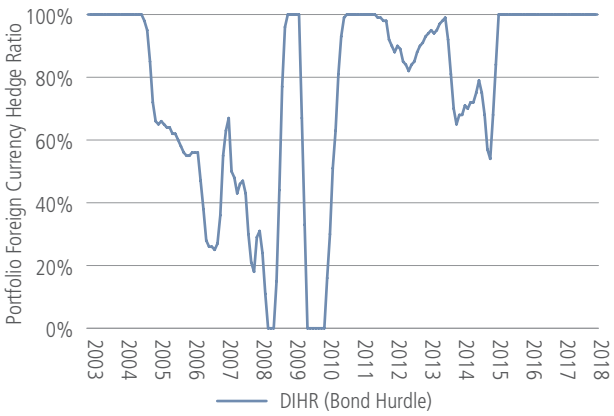
Insurance Proxy Portfolios with Bond Hurdle: Does the DIHR Remove Currency Hedges?

Yes. Between 2003 and 2018, the DIHR framework handicapped with the corporate bond hurdle rate allowed for the periodic lifting of hedges.

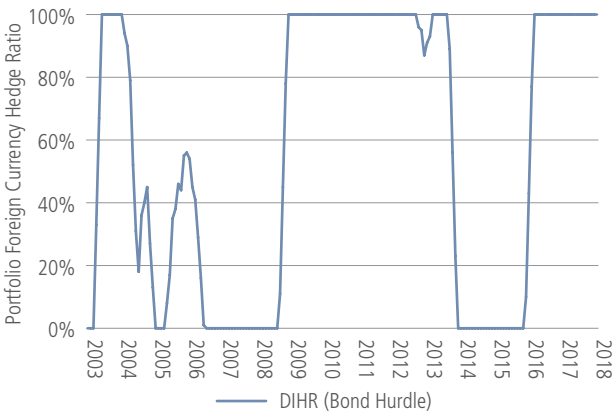
The EUR-based portfolio would have been less than fully hedged 60% of the time. The GBP-based portfolio would have been less than fully hedged 53% of the time.

FIGURE 6. SOLVENCY II-RELATED ADJUSTMENTS WOULD NOT HAVE CONSTRAINED THE DIHR FROM PERIODICALLY LIFTING HEDGES

Simulated Dynamic Ideal Hedge Ratio for a EUR-based investor in an insurance proxy portfolio—bond hurdle DIHR framework



Simulated Dynamic Ideal Hedge Ratio for a GBP-based investor in an insurance proxy portfolio—bond hurdle DIHR framework



Source: Bloomberg, MSCI, Neuberger Berman Europe Limited calculations. Period under review is 31 January 2003 to 28 February 2018.

Insurance Proxy Portfolios with Bond Hurdle: Are Results Improved?

Yes. Had the EUR-based insurer maintained a 100% hedge, it would have achieved a 4.94% annualized return with 3.95% volatility, a return-to-risk ratio of 1.25. Had it deployed the DIHR framework with the corporate bond hurdle, the return would have risen to 5.37% and the volatility would have declined to 3.89%, a return-to-risk ratio of 1.38. This would have been achieved while generating 1.69% of additional Solvency II capital requirements, on average.

For comparison, a static 0% or 50% hedged strategy would have delivered a lower return-to-risk ratio while generating 6.92% and 3.46% of additional solvency capital requirements, respectively. Similar results for the GBP-based portfolio are shown in the summary table in figure 7.

FIGURE 7. SUMMARY RESULTS FOR INSURANCE PROXY PORTFOLIOS WITH BOND HURDLE

		Ann. return	Ann. volatility	Return / risk ratio	Average additional solvency capital	Return improvement (versus 100% hedged) per unit of average additional solvency capital	Return/risk ratio improvement (versus 100% hedged) per unit of average additional solvency capital
EUR-based insurance proxy portfolio investors	100% hedged	4.94%	3.95%	1.25	0.00%	**NA**	**NA**
	50% hedged	4.96%	3.81%	1.30	3.46%	**0.00**	**-0.82**
	0% hedged	4.95%	4.15%	1.19	6.92%	**0.00**	**-0.82**
	DIHR with bond hurdle	5.37%	3.89%	1.38	1.69%	**0.25**	**7.51**
GBP-based insurance proxy portfolio investors	100% hedged	5.86%	4.43%	1.32	0.00%	**NA**	**NA**
	50% hedged	6.06%	4.56%	1.33	4.14%	**0.05**	**0.20**
	0% hedged	6.25%	5.03%	1.24	8.27%	**0.05**	**-0.98**
	DIHR with bond hurdle	6.44%	4.57%	1.41	3.51%	**0.16**	**2.44**

Source: Bloomberg, Neuberger Berman calculations. Period under review is 31 January 2003 to 28 February 2018.

A summary table showing consolidated results for all 18 of the tests that we carried out is shown on the last page of this paper.

SUMMARY RESULTS FOR 18 DIFFERENT STRATEGIES

			Ann. return	Ann. volatility	Return / risk ratio	Average additional solvency capital	Return improvement (versus 100% hedged) per unit of average additional solvency capital	Return/risk ratio improvement (versus 100% hedged) per unit of average additional solvency capital
EUR-BASED INVESTORS	Insurance proxy portfolio investors	100% hedged	4.94%	3.95%	1.25	0.00%	**NA**	**NA**
		50% hedged	4.96%	3.81%	1.30	3.46%	**0.00**	**-0.82**
		0% hedged	4.95%	4.15%	1.19	6.92%	**0.00**	**-0.82**
		DIHR with equity future hurdle	5.44%	3.79%	1.44	1.81%	**0.28**	**10.18**
		DIHR with bond hurdle	5.37%	3.89%	1.38	1.69%	**0.25**	**7.51**
	MSCI World investors	100% hedged	5.78%	12.87%	0.45	0.00%	**NA**	**NA**
		50% hedged	5.99%	11.91%	0.50	10.79%	**0.02**	**0.50**
		0% hedged	6.06%	11.96%	0.51	21.59%	**0.01**	**0.27**
		DIHR with equity future hurdle	7.15%	11.77%	0.61	7.32%	**0.19**	**2.17**
		DIHR with bond hurdle	NA	NA	NA	NA	**NA**	**NA**
GBP-BASED INVESTORS	Insurance proxy portfolio investors	100% hedged	5.86%	4.43%	1.32	0.00%	**NA**	**NA**
		50% hedged	6.06%	4.56%	1.33	4.14%	**0.05**	**0.20**
		0% hedged	6.25%	5.03%	1.24	8.27%	**0.05**	**-0.98**
		DIHR with equity future hurdle	6.58%	4.57%	1.44	3.41%	**0.21**	**3.44**
		DIHR with bond hurdle	6.44%	4.57%	1.41	3.51%	**0.16**	**2.44**
	MSCI World investors	100% hedged	6.88%	12.86%	0.54	0.00%	**NA**	**NA**
		50% hedged	7.62%	12.17%	0.63	11.31%	**0.07**	**0.80**
		0% hedged	8.22%	12.54%	0.66	22.61%	**0.06**	**0.53**
		DIHR with equity future hurdle	8.96%	12.19%	0.73	9.31%	**0.22**	**2.14**
		DIHR with bond hurdle	NA	NA	NA	NA	**NA**	**NA**

Source: Bloomberg, Neuberger Berman calculations. Period under review is 31 January 2003 to 28 February 2018. The simulated backtested performance of the Dynamic Ideal Hedge Ratio approach has been calculated by applying the Dynamic Ideal Hedge Ratio to the underlying index on a monthly basis at month end. Figures are quoted gross of fees. The returns presented reflect hypothetical performance an investor would have obtained had it invested in the manner shown and does not represent returns that any investor actually attained. The information presented is based upon the following hypothetical assumptions. Certain of the assumptions have been made for modelling purposes and are unlikely to be realized. No representation or warranty is made as to the reasonableness of the assumptions made or that all assumptions used in achieving the returns have been stated or fully considered. Changes in the assumptions may have a material impact on the hypothetical returns presented. Returns are gross of tax and fees and include average expected currency transactions costs over time. **Past performance does not guarantee future results.**

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