Dimensional

To Hedge or Not to Hedge: A Framework for Currency Hedging Decisions in Global Equity & Fixed Income Portfolios

Wei Dai, Warwick Schneller

October, 2020

This paper develops a framework for evaluating the impact of currency hedging on expected returns and volatility and tests the implications for global equity and fixed income portfolios using data on 12 developed markets from 1985 to 2019. We show that the impact of currency hedging on overall portfolio volatility depends on the magnitude of asset volatility relative to that of currency volatility. We also find that currency returns cannot be reliably predicted using the prior month currency returns or interest rate differentials. The forward currency premium, however, contains reliable information about differences in expected returns between unhedged and hedged portfolios, and can be used to pursue higher expected returns through a selectively hedged strategy.

We would like to thank Savina Rizova and Marlena Lee for their helpful comments.

Abstract

This paper develops a framework for evaluating the impact of currency hedging on expected returns and volatility and tests the implications for global equity and fixed income portfolios using data on 12 developed markets from 1985 to 2019. We show that the impact of currency hedging on overall portfolio volatility depends on the magnitude of asset volatility relative to that of currency volatility. We also find that currency returns cannot be reliably predicted using the prior month currency returns or interest rate differentials. The forward currency premium, however, contains reliable information about differences in expected returns between unhedged and hedged portfolios, and can be used to pursue higher expected returns through a selectively hedged strategy.

Introduction

Currency movements can have important effects on the returns of unhedged foreign investments. While currency hedging can reduce the impact of currency movements on portfolio returns, an informed decision on whether and when to hedge currency exposure depends on many factors. In this paper, we develop and test a framework that can be used to evaluate the impact of currency hedging on expected returns and volatility while informing currency hedging decisions based on different asset allocations and investment goals.

We decompose the expected return and variance of a foreign asset on an unhedged and hedged basis. The difference in expected returns between an unhedged and a hedged foreign asset depends on the expected currency return and the forward currency premium (discount). The volatility impact of currency hedging is mainly determined by the variance of the asset return, the variance of the currency return, and the covariance between asset and currency returns. Based on this decomposition, we examine empirically the relevance of each component for currency hedging decisions.

Using data on 12 developed markets currencies from January 1985 to December 2019, we find that average monthly currency returns are not reliably different from zero. We also find that monthly currency movements cannot be consistently predicted using past currency returns or interest rate differentials. This finding is consistent with the academic evidence, which also suggests that currency movements are difficult to predict in the short to medium term in a manner that is relevant for making investment decisions. However, the forward currency premium (discount), which is based on observable currency spot and forward rates, contains reliable information about differences in expected returns between an unhedged and hedged global portfolio.

The impact of currency hedging on volatility depends mostly on the magnitude of asset volatility relative to that of currency volatility. Using equity, fixed income, and currency data for 12 developed markets, we find that the volatility of stocks tends to be higher than that of currencies, and, as a result, unhedged and hedged developed markets equity portfolios tend to have similar volatility. For fixed income, however, currency volatility dominates the overall portfolio volatility if left unhedged.

Consequently, for developed markets portfolios with high allocations to fixed income, hedging currency exposure leads to a meaningful reduction in volatility.

Based on these findings, we construct selectively hedged developed markets equity and fixed income strategies that dynamically vary currency exposure based on observable forward currency premiums. Currencies are only hedged in months when the forward currency premium at the beginning of the month is positive, indicating that the expected return is higher for the hedged than the unhedged currency. Over the full sample period from January 1985 to December 2019, for both developed markets equity and fixed income strategies, a selectively hedged strategy that equally weights countries outperforms the always hedged and always unhedged counterparts as well as a strategy that maintains a static hedge with the same time-series average hedge ratio. For developed markets equities, the selectively hedged portfolio generates an annualized outperformance of 0.6%, 2.2%, and 1.2% relative to the unhedged, hedged, and static portfolios, respectively. Volatility is similar across these portfolios, ranging from 13.9% to 16.3% per year. For developed markets fixed income, volatility increases meaningfully with currency exposure: the annualized volatility is 1.3% for the always hedged portfolio, 4.7% for the selectively hedged portfolio, and 7.5% for the always unhedged portfolio. In terms of annualized returns, the selectively hedged portfolio outperforms hedged, static, and unhedged portfolios by 2.0%, 1.1%, and 0.5%, respectively. Importantly, this approach to increasing expected returns uses the information in current forward currency premiums and does not rely on forecasting exchange rates. Taken together, these results suggest that a global equity investor can use currency hedging decisions informed by forward currency premiums to increase expected returns without substantially increasing portfolio volatility. When the majority of investments are in fixed income, selectively hedged strategies can be appropriate for those who are willing to accept more volatility in pursuit of higher expected returns.

This paper provides guidance on how investors with global portfolios may approach currency hedging decisions. Our results on exchange rate predictability confirm the previous literature documenting the empirical failure of uncovered interest rate parity (UIRP), especially at short horizons (see, for example, Fama, 1984; Chinn and Quayyum, 2012; Ismailov and Rossi, 2018), and are consistent with much of the empirical work concluding that accurately predicting foreign exchange movements remains an extremely challenging task (see, for example, Meese and Rogoff, 1983; Fama, 1984; Taylor, 1995; Cheung, Chinn, and Pascual, 2005; Rogoff and Stavrakeva, 2008; Rogoff, 2009; Rossi, 2013; Calomiris and Mamaysky, 2019). Our finding that the forward currency premium can help inform currency hedging decisions is related to and consistent with the currency carry-trade literature (see, for example, Burnside, Eichenbaum, Kleshchelski and Rebelo, 2010; Lustig, Roussanov and Verdelhan, 2011; Barroso and Santa-Clara, 2015; Jurek, 2014; Daniel, Hodrick and Lu, 2014). More broadly, this paper contributes to the literature on the role currencies have in capital markets and the optimal currency exposures for investors, (see, for example, Black, 1990; Glen and Jorion, 1993; Campbell, Serfaty-de Medeiros and Vicerira, 2010; and Ranaldo and Söderlind, 2010).

The rest of the paper is organized as follows: Section 1 outlines the general currency hedging problem and develops a framework to evaluate hedging decisions; Section 2 describes the equity, fixed income, and currency data used in this study; Section 3 presents the empirical results; and Section 4 concludes.

1. Framework for Evaluating Currency Hedging Decisions

We will start with one foreign asset and generalize to a portfolio with multiple foreign assets. Consider a US investor who holds a foreign asset *i* and measures its returns in US dollars over an investment horizon from *t* to *t+1*. We follow a similar framework to Glen and Jorion (1993), defining $S_{i,t}$ as the spot US dollar price of foreign currency at time *t* and $P_{i,t}$ as the value of the foreign asset denominated in foreign currency observable at time *t.* At the end of each investment period, the total return in US dollars from time *t* to *t+1* on an unhedged foreign investment, $R^{UH}_{i,t+1}$, is measured as:

$$R^{UH}_{i,t+1} = \frac{P_{i,t+1}\, S_{i,t+1}}{P_{i,t}\, S_{i,t}} - 1 \qquad (1)$$

Equation (1) can be restated as:

$$\begin{aligned} R^{UH}_{i,t+1} &= \left(1 + \frac{P_{i,t+1} - P_{i,t}}{P_{i,t}}\right) \times \left(1 + \frac{S_{i,t+1} - S_{i,t}}{S_{i,t}}\right) - 1 \\ &= \left(1 + R^{a}_{i,t+1}\right) \times \left(1 + R^{c}_{i,t+1}\right) - 1 \\ &= R^{a}_{i,t+1} + R^{c}_{i,t+1} + R^{a}_{i,t+1} R^{c}_{i,t+1} \end{aligned} \qquad (2)$$

where $R^{a}_{i,t+1} = \frac{P_{i,t+1} - P_{i,t}}{P_{i,t}}$ is the return of the foreign asset denominated in the foreign currency and $R^{c}_{i,t+1} = \frac{S_{i,t+1} - S_{i,t}}{S_{i,t}}$ is the return on the currency over the same period. From equation (2) we see that, when an investor buys an asset denominated in a foreign currency on an unhedged basis, its return is determined by both the return of the foreign asset and the return of the currency.

To manage the component of returns due to currency exposures, investors can sell a currency forward at *t* for exchange at *t+1,* locking in the future exchange rate. The forward rate, $F_{i,t}$, represents the exchange rate at which market participants agree today to exchange foreign currency for US dollars at a future date *t+1*. Both the forward rate and spot rate are market prices observable at time *t*, reflecting the actions and expectations of market participants.

More generally, if the investor hedges the currency exposure by selling currency forward at time *t* for a portion of the initial value of the investment, the return from time *t* to *t+1* is:

$$R^{h_i}_{i,t+1} = R^{a}_{i,t+1} + R^{c}_{i,t+1} + R^{a}_{i,t+1} R^{c}_{i,t+1} + h_i\left(FCP_{i,t} - R^{c}_{i,t+1}\right) \qquad (3)$$

where the hedge ratio $h_i \in [0,1]$ is the percentage of the initial value hedged and $FCP_{i,t} = \frac{F_{i,t}}{S_{i,t}} - 1$ is referred to as the forward currency premium (discount). In the case of $h_i = 0$, the currency exposure of the investment is unhedged and we are back to equation (2). On the other hand, $h_i = 1$ implies that the initial value of the asset is fully hedged (denoted as "FH") and the equation simplifies to:

$$R_{i,t+1}^{FH} = R_{i,t+1}^{a} + R_{i,t+1}^{a} R_{i,t+1}^{c} + FCP_{i,t} \tag{4}$$

Note that a hedge ratio equal to 1 does not completely eliminate the currency risk of the foreign asset due to market movements between *t* and *t+1* that cause the value of foreign assets to deviate from initial value. The interaction between asset movement and currency exposure is represented by the cross term $R_{i,t+1}^{a} R_{i,t+1}^{c}$, which is typically second order, especially if the time interval between *t* and *t+1* is small.

Covered interest rate parity[1] (CIRP) implies the forward currency premium (discount) is related to the interest rate differential between the home and foreign market. That is, $FCP_{i,t} = \frac{(1+i_t)}{(1+i_t^*)} - 1$, where i_t is the home country interest rate and i_t^* is the foreign country interest rate at *t*. $FCP_{i,t}$ is positive (premium) when $i_t > i_t^*$ and negative (discount) when $i_t < i_t^*$.

Taking the expectation of equation (3) at time *t* gives:

$$E(R_{i,t+1}^{h_i}) = E(R_{i,t+1}^{a}) + E(R_{i,t+1}^{c}) + E(R_{i,t+1}^{a})E(R_{i,t+1}^{c}) + Cov(R_{i,t+1}^{a}, R_{i,t+1}^{c}) + h_i\left(FCP_{i,t} - E(R_{i,t+1}^{c})\right) \tag{5}$$

The first four terms of equation (5) do not depend on hedging choices, or h_i. The last term reflects the effect of currency hedging on expected returns. That is, the expected return difference between a partially or fully hedged (h_i>0) and an unhedged (h_i=0) foreign investment depends on the hedge ratio, expected currency returns, and the forward currency premium:

$$E(R_{i,t+1}^{h_i}) - E(R_{i,t+1}^{UH}) = h_i\left(FCP_{i,t} - E(R_{i,t+1}^{c})\right) \tag{6}$$

When the asset is fully hedged (h_i=1), equation (6) simplifies to:

$$E(R_{i,t+1}^{FH}) - E(R_{i,t+1}^{UH}) = FCP_{i,t} - E(R_{i,t+1}^{c}) \tag{7}$$

The variance of a foreign asset with hedge ratio h_i is:

$$var(R_{i,t+1}^{h_i}) = var(R_{i,t+1}^{a}) + (1-h_i)^2 var(R_{i,t+1}^{c}) + 2(1-h_i)cov(R_{i,t+1}^{a}, R_{i,t+1}^{c}) + \Delta V_i \tag{8}$$

where ΔV represents the contribution of the FCP-related terms and other cross-product terms to the total variance of the asset return. These will generally be second order effects.

The variance of an unhedged foreign asset (h_i=0) is determined by the variance of both the foreign asset and the foreign currency.

$$var(R_{i,t+1}^{UH}) = var(R_{i,t+1}^{a}) + var(R_{i,t+1}^{c}) + 2cov(R_{i,t+1}^{a}, R_{i,t+1}^{c}) + \Delta V_i^{UH} \tag{9}$$

[1] For CIRP to hold perfectly, several assumptions must be met. First, there must not be any hindrance to arbitrage across countries. Second, transaction costs must be zero. Third, there must be no difference in expected loss from default. In reality, it is sensible to expect deviation from CIRP to occur due to differences in credit quality, regulatory effects, clientele effects, and trading costs, among other things.

In the case where the foreign asset currency exposure is fully hedged (h_i=1), equation (8) simplifies to:

$$var\left(R_{i,t+1}^{FH}\right) = var\left(R_{i,t+1}^{a}\right) + \Delta V_i^{FH} \tag{10}$$

Therefore, differences in variances between hedged and unhedged foreign assets are driven by currency variance and the covariance between asset and currency returns.

While we have focused on one foreign asset so far, the same framework can be generalized to a portfolio of multiple foreign assets. Extending equation (5), the expected return of a portfolio p of N foreign assets with weights $\{w_i\}_{i=1\ldots,N}$ and hedge ratios $\{h_i\}_{i=1\ldots,N}$ is:

$$\begin{aligned} E\left(R_{p,t+1}^{\{h_i\}}\right) = & \sum_{i=1}^{N} w_i \Big(E\left(R_{i,t+1}^{a}\right) + E\left(R_{i,t+1}^{c}\right) + E\left(R_{i,t+1}^{a}\right)E\left(R_{i,t+1}^{c}\right) + Cov\left(R_{i,t+1}^{a}, R_{i,t+1}^{c}\right) \\ & + h_i\left(FCP_{i,t} - E\left(R_{i,t+1}^{c}\right)\right)\Big) \end{aligned} \tag{11}$$

where $\sum_{i=1}^{N} w_i = 1$.

Similarly, the variance is:

$$\begin{aligned} var\left(R_{p,t+1}^{\{h_i\}}\right) = & \sum_{i=1}^{N} w_i^2 \left(var\left(R_{i,t+1}^{a}\right) + (1-h_i)^2 var\left(R_{i,t+1}^{c}\right)\right) \\ & +2\sum_{i=1}^{N}\sum_{j=1}^{N} w_i w_j (1-h_j) cov\left(R_{i,t+1}^{a}, R_{j,t+1}^{c}\right) \\ & + \Delta V_p \end{aligned} \tag{12}$$

The decomposition of expected returns and variance provides a framework for what drives differences between hedged (fully or partially) and unhedged portfolios with foreign asset exposure. The questions then become: what can we say about these components, and how should they inform currency hedging decisions? In the following sections, we address these questions empirically.

2. Data and Summary Statistics

We obtain equity, fixed income, and currency data from January 1985[2] to December 2019 for 12 developed markets: Australia, Canada, Denmark, Germany[3], New Zealand, Norway, Japan, Singapore, Sweden, Switzerland, the UK, and the US. Monthly equity returns are measured using MSCI country indices, and fixed income returns are measured using country carve-outs of the FTSE World Government Bond 1-3 Years Index. Both equity and fixed income returns for each market are measured in the respective local currency. Monthly spot and forward exchange rates are from MSCI. Currency returns are calculated with the US as the home market.

[2] Not all data series start from January 1985 due to data availability. As described in the appendix, local equity returns start from February 1986 for Denmark and January 1988 for New Zealand. Local fixed income returns start from April 1989 for Denmark, October 1992 for New Zealand, January 1995 for Norway, May 2000 for Singapore, and January 1991 for Sweden.

[3] Germany was the largest economy at the beginning of the euro in December 1999 and is used as a proxy for the European monetary union. This choice also allows us to cover the period prior to the formation of the European monetary union for currency returns.

Table 1 reports summary statistics for the local equity, local fixed income, and currency monthly returns across markets. Over the sample period, the average returns for currencies tend to be small and not reliably different from zero for any of the 11 developed markets currency pairs. In comparison, average local equity returns are between 0.4% and 1.3% per month and are more than two standard errors above zero for all but Japan. Average local fixed income returns range between 0.1% and 0.6% per month and are all more than seven standard errors from zero.

As shown in the third column of Table 1, monthly standard deviations of fixed income returns are less than 1% for all markets, much lower than those of equity and currency returns. The monthly standard deviations of equity returns range between 4.2% and 6.5% across markets, while currency returns are less volatile than stocks, with monthly standard deviations between 1.6% and 3.5%.

3. Results

3.1 What Can We Say About Unhedged vs. Hedged Returns?

In this section, we study the differences in expected returns between an unhedged and hedged foreign investment, which, as shown in equation (6), depend on expected currency returns, $E\left(R_{i,t+1}^{c}\right)$, and the forward currency premium, $FCP_{i,t}$. To examine how each component can affect hedging decisions, we begin with the first component, currency returns.

We first test whether there is predictable persistence or reversal in monthly currency returns. Equation (13) shows the regression setup, where this month's currency returns are used to predict currency returns one month ahead. Spot exchange rates are expressed as logs, i.e., $s_t = \ln(S_t)$, as in Fama (1984).

$$s_{t+1} - s_t = \alpha + \beta(s_t - s_{t-1}) + \varepsilon_{t+1} \tag{13}$$

As reported in **Table 2**, the estimated slope coefficients are positive for some countries (Australia, Denmark, Germany, Norway, Singapore, Sweden, and the UK) and negative for others (Canada, Japan, New Zealand, and Switzerland). More importantly, the corresponding t-statistics are between 0.32 and 1.66 in absolute value across counties, which suggests this month's currency return is not a reliable predictor for next month's currency return. In addition, the R-squared is less than 0.7% for all countries, indicating that the vast majority of the variation in currency returns over the next month is unexplained by the current month's currency returns.

Next, we test UIRP, which is empirically rejected by existing studies, especially at short horizons (see, for example, Fama, 1984; Chinn and Quayyum, 2012; Ismailov and Rossi, 2018). UIRP hypothesizes that, in a risk-neutral world, the foreign interest rate plus the expected currency return should equal the domestic interest rate. In other words, if the foreign interest rate is higher than the domestic interest rate, the foreign currency is expected to depreciate to offset the interest rate differential, and vice versa, such that investors are indifferent among interest rate levels across countries. Since, as suggested by CIRP, interest rate differentials are directly related to forward currency premiums, we can test UIRP using the following specification, where monthly currency returns are regressed on the forward currency premiums (expressed in logs), i.e., $s_t = \ln(S_t)$ and $\ln(1 + FCP_t) = \ln(F_t) - \ln(S_t) = f_t - s_t$,

$$s_{t+1} - s_t = \alpha + \beta(f_t - s_t) + \varepsilon_{t+1} \tag{14}$$

If UIRP holds, β should be one. Consistent with the existing literature, results in **Table 3** reject the predictive power of forward currency premiums for currency returns, as none of the coefficients across the 11 countries have a t-statistic above 2.[4] Several of the β's are negative, implying that exchange rates move in the opposite direction than predicted by UIRP.

The lack of predictability in monthly currency movements suggests that there is not much we can say about the variation in the conditional expectation of short-term currency returns and that, effectively, we can replace the conditional mean of short-term currency returns with their unconditional mean. Since average monthly currency returns are not reliably different from zero as shown in Table 1, it is reasonable to use zero as the unconditional expectation of monthly currency returns. That is, we can replace $E\left(R_{i,t+1}^{c}\right)$ with zero and rewrite equation (6) as follows:

$$E\left(R_{i,t+1}^{h_i}\right) = E\left(R_{i,t+1}^{UH}\right) + h_i FCP_{i,t} \tag{15}$$

That means that the forward currency premium, which is observable at time *t*, contains information about differences in expected returns between hedged and unhedged portfolios.

3.2 Portfolio Volatility: Unhedged vs. Hedged

As shown in equation (9), the variance of an unhedged foreign asset can be evaluated based on the contribution of four components: the variance of local asset returns, $var\left(R_{i,t+1}^{a}\right)$; the variance of currency returns, $var\left(R_{i,t+1}^{c}\right)$; the covariance of the asset and currency returns, $cov\left(R_{i,t+1}^{a}, R_{i,t+1}^{c}\right)$; and the contribution of cross-product terms, ΔV_i^{UH}. In this section, we examine the relative importance of each component and discuss the implications for hedging decisions.

Among these components, $var\left(R_{i,t+1}^{a}\right)$ is the main contributor to the variance of hedged return as shown in equation (10). While currency hedging also exposes investors to the variability related to the forward currency premium, $FCP_{i,t}$, the impact is usually secondary. This should not be surprising as the forward currency premium is related to the short-term interest rate differential, which tends to be slow moving compared to currencies. Indeed, over the sample period January 1985 to December 2019, the volatility of currency returns across the 11 currencies against the US dollar ranges from 1.58% to 3.46% per month vs. 0.13% to 0.36% per month for forward currency premiums. This is further illustrated in **Figure 1** using the AUD/USD currency pair as an example.

Table 4 reports the variance decomposition of unhedged foreign asset returns. Panel A reports the results for equity and Panel B for fixed income. For unhedged equity returns, the total volatility ranges between 4.9% and 7.3% per month across individual countries. The main driver of total

[4] Deviations from UIRP may be due to the presence of a time-varying foreign exchange risk premium that is not fully diversifiable (Fama, 1984). Such a premium could exist if market participants are risk averse, rather than risk neutral, an assumption of UIRP. Market participants may demand a higher rate of return than the interest rate differential for holding an asset in one currency rather than in another, and therefore the interest rate differential would be equal to the expected change in the exchange rate plus a risk premium.

variance is the variance of asset returns, contributing between 49.9% and 87.3%, and 74.6% on average, for investments outside the US home market. In comparison, the variance of currencies is lower and makes a less significant contribution, 24.9% on average. The contribution of the covariance of country level stock indices and currencies can be positive or negative depending on the direction of co-movement. For example, over the sample period, exchange rate movements in Australia and Canada reinforce the stock market movement, while in Germany, Japan, Switzerland, and the UK they offset it. While the contribution for individual countries varies between –33.9% and 24.7%, on average it is only 0.6%. Overall, the results show that stocks tend to be more volatile than currencies and that the variance of unhedged stock returns tends to be dominated by the component of local stock returns.

For unhedged fixed income returns, the total volatility ranges across individual countries from 1.7% to 3.5% per month. The main driver of variance for unhedged fixed income returns is the variance of currency returns, contributing 96.8% on average for investments outside of the US home market, with individual country estimates ranging between 89.6% and 104.9%. The contribution can exceed 100% due to a negative contribution from the covariance and/or cross-product terms. In comparison, the variance of local fixed income returns is lower, contributing 3.4% on average and ranging from 1.3% to 8.8% across individual countries. Covariance and higher order terms also tend to be second order effects relative to currency variance. The results show that, for a developed markets fixed income portfolio, currency exposure can lead to a significant increase in volatility.

Consistent with the findings above, **Figure 2** plots the monthly returns for value-weighted (market cap weights across countries) developed markets portfolios on an unhedged vs. hedged basis from a US investor's perspective over the sample period from January 1985 to December 2019. Panel A demonstrates that, in a developed markets equity portfolio, hedging currencies does not meaningfully reduce return volatility, while Panel B shows substantial volatility reduction from currency hedging for a developed markets fixed income portfolio.

What about an asset allocation that combines fixed income and equities? **Table 5** shows the percentage reduction in volatility through currency hedging increases monotonically as the fixed income allocation increases in a balanced portfolio. For example, the reduction in total portfolio volatility is 8.1% for an allocation that invests 80% in developed markets equities. In comparison, for an allocation with 80% in developed markets fixed income, the reduction in total portfolio volatility from currency hedging is more than 40%.

3.3 Putting It All Together: Selective Hedging

Always hedged and always unhedged portfolios are not the only two choices available to investors. The forward currency premium can be used to inform dynamic currency hedging decisions in pursuit of higher expected returns. We test the efficacy of this approach by simulating selectively hedged strategies where one-month ahead currency hedging decisions are based on the observable forward currency premiums. In particular, the strategies hedge the currency exposure in markets where the observed forward currency premium is positive and leave the currency exposure unhedged otherwise:

$$h_{i,t} = \begin{cases} 1, & FCP_{i,t} > 0 \\ 0, & otherwise \end{cases} \quad (16)$$

For comparison, we also simulate statically hedged strategies that have constant hedge ratios for each currency, equal to the time-series average hedge ratios of the selectively hedged counterparts, i.e., $h_i^{static} = \frac{1}{T}\sum_{t=1}^{T} h_{i,t}$.

Panel A of **Table 6** reports the performance of selectively hedged strategies vs. always unhedged and always hedged strategies, as well as static hedging strategies for developed markets equity and fixed income strategies from January 1985 to December 2019, where countries are equal weighted. For both equity and fixed income, the selectively hedged strategies outperform their corresponding static counterparts, which by design have the same time-series average hedge ratio. The annualized compound return of the selectively hedged equity strategy is 11.9%, compared with 10.7% for the static strategy. In the case of fixed income, the selectively hedged portfolio returned 6.4% annualized, outperforming the return of 5.4% for the static hedging portfolio. These results confirm the efficacy of a dynamic hedging approach based on forward currency premiums, controlling for average hedge ratio.

The selectively hedged strategy also outperforms the unhedged and hedged strategies for both equity and fixed income, the relevant comparison for many investors. For equities, the annualized return of the selectively hedged equity portfolio is 11.9%, an annualized outperformance of 0.6% and 2.2% compared with the unhedged and hedged portfolios, respectively. Annualized volatility is similar across equity portfolios with different currency hedging decisions, ranging from 13.9% to 16.3%. For fixed income, the hedging decision has a meaningful impact on portfolio volatility, as expected: annualized volatility increases from 1.3% for the always hedged to 4.7% for the selectively hedged and to 7.5% for the always unhedged. The selectively hedged portfolio delivers 6.4% annualized, outperforming the always hedged and always unhedged portfolios by 2.0% and 0.5%, respectively.

Panel B of Table 6 reports the percentage of months hedged by country for the full sample period, which depends on the forward currency premium (discount) between the home (US) and foreign market. For example, the Japanese yen has generally traded at a forward currency premium to the US dollar, resulting in 92% of months being hedged for holdings in Japan. On the other hand, the New Zealand dollar has generally traded at a forward currency discount to the US dollar, implying that the expected unhedged return is larger, and, as a result, only 11% of months have been hedged for New Zealand stocks over the full sample period.

In addition, as forward currency premiums change over time, the composition of hedged currencies varies dynamically. As shown in **Figure 3**, the percentage of countries hedged for a stock portfolio that equally weights countries ranges between zero and 92% over the full sample period. For example, in June 2017, 9 of 11 currencies were hedged to the US dollar, making up 75% of the portfolio weight, while in March 1991 the selectively hedged stock portfolio did not hedge any of the 11 currencies.

4. Conclusion

The return on foreign investments is determined by both the return of foreign assets and the return of currencies. There is little evidence to support the predictability of exchange rate movements using previous months' currency returns or interest rates, implying that investors can dynamically use the information in forward currency premiums to increase expected returns.

The results shed light on how currency hedging decisions depend on portfolio composition and investment goals. For a global portfolio with a high equity allocation, hedging currencies tends not to reduce return volatility by a significant amount. Consequently, currency hedging decisions informed by forward currency premiums can increase expected returns without substantially increasing portfolio volatility. In contrast, when the majority of the investments are in fixed income, currency hedging can be an effective way to reduce the volatility of the total portfolio. Therefore, completely hedging foreign exchange exposure may be appropriate for investors who prefer lower volatility from their global fixed income investments, while selectively hedged strategies can add value for those who are willing to accept more volatility in pursuit of higher expected returns. Investors should think through these implications in order to make an informed currency hedging decision consistent with their investment preferences and goals.

Tables

TABLE 1

Summary Statistics for Monthly Equity, Fixed Income, and Currency Returns

The table presents the summary statistics for local equity, local fixed income, and currency monthly returns across 12 developed markets. The sample period for most countries is January 1985 to December 2019. Local equity returns start from February 1986 for Denmark and January 1988 for New Zealand. Local fixed income returns start from April 1989 for Denmark, October 1992 for New Zealand, January 1995 for Norway, May 2000 for Singapore, and January 1991 for Sweden. Panel A reports local equity returns based on MSCI country indices (gross div.) in each country's local currency. Panel B reports local fixed income returns, measured using the country carve-outs of the FTSE Government Bond 1-3 Years Index. Panel C reports currency returns of 11 major currencies against the US dollar using monthly spot exchange rates data from MSCI. Returns and standard deviations are expressed as monthly percentage points.

PANEL A: LOCAL EQUITY RETURNS

	Mean	$t(\text{mean})$	Std. Dev.	Minimum	Maximum
Australia	1.01	4.61	4.50	-41.28	14.76
Canada	0.81	3.98	4.15	-21.58	12.83
Denmark	1.06	4.13	5.20	-18.07	18.84
Germany	0.87	2.96	6.00	-24.93	20.94
Japan	0.42	1.57	5.54	-21.05	20.05
New Zealand	0.71	2.75	5.07	-17.36	26.17
Norway	0.98	3.17	6.36	-29.69	16.39
Singapore	0.75	2.36	6.48	-41.86	23.71
Sweden	1.27	4.04	6.46	-21.52	34.96
Switzerland	0.89	3.95	4.61	-23.23	14.09
UK	0.82	3.91	4.32	-25.93	14.70
US	1.00	4.78	4.28	-21.22	13.28

PANEL B: LOCAL FIXED INCOME RETURNS

	Mean	$t(\text{mean})$	Std. Dev.	Minimum	Maximum
Australia	0.59	16.84	0.71	-2.27	2.81
Canada	0.45	13.55	0.67	-2.39	3.07
Denmark	0.36	12.36	0.55	-1.33	3.25
Germany	0.32	14.89	0.44	-0.75	2.48
Japan	0.17	8.69	0.41	-1.59	2.31
New Zealand	0.44	15.11	0.52	-1.33	2.46
Norway	0.28	9.81	0.50	-2.13	2.64
Singapore	0.14	7.89	0.26	-0.79	1.28
Sweden	0.38	12.26	0.57	-0.92	3.74
Switzerland	0.21	10.06	0.43	-1.76	2.12
UK	0.47	14.68	0.66	-2.45	3.91
US	0.39	15.58	0.52	-0.99	2.44

PANEL C: CURRENCY RETURNS (HOME CURRENCY USD)

	Mean	$t(\text{mean})$	Std. Dev.	Minimum	Maximum
Australia	0.02	0.10	3.33	-15.72	10.41
Canada	0.03	0.26	2.15	-12.21	9.25
Denmark	0.17	1.17	3.00	-10.79	10.20
Germany	0.19	1.26	3.06	-10.61	10.09
Japan	0.26	1.54	3.45	-20.93	17.75
New Zealand	0.14	0.85	3.46	-13.07	13.32
Norway	0.06	0.38	3.10	-12.85	8.12
Singapore	0.13	1.66	1.58	-7.74	5.96
Sweden	0.04	0.27	3.19	-14.76	9.56
Switzerland	0.29	1.80	3.31	-11.21	13.56
UK	0.08	0.53	2.91	-12.08	14.10

Past performance is not a guarantee of future results.

TABLE 2

Test of Autocorrelation of Monthly Currency Returns

The table reports results for predictive regressions of next month's currency return on current month's currency return for each of the 11 currencies against the US dollar. The specification is $s_{t+1} - s_t = \alpha + \beta(s_t - s_{t-1}) + \varepsilon_{t+1}$, where spot exchange rates are expressed in logs i.e., $s_t = \ln(S_t)$. The table shows the regression intercepts(α), slope coefficients (β), and adjusted R^2 (R^2). T-statistics are reported in parenthesis. The sample period is January 1985 to December 2019.

Currency (Base Currency USD)	α	β	R^2
Australia	-0.00 (-0.26)	0.04 (0.87)	0.2%
Canada	0.00 (0.05)	-0.05 (-0.97)	0.2%
Denmark	0.00 (0.81)	0.02 (0.32)	0.0%
Germany	0.00 (0.90)	0.02 (0.42)	0.0%
Japan	0.00 (1.27)	-0.06 (-1.21)	0.4%
New Zealand	0.00 (0.45)	-0.02 (-0.35)	0.0%
Norway	0.00 (0.01)	0.03 (0.67)	0.1%
Singapore	0.00 (1.46)	0.02 (0.35)	0.0%
Sweden	-0.00 (-0.08)	0.08 (1.66)	0.7%
Switzerland	0.00 (1.50)	-0.03 (-0.53)	0.1%
UK	0.00 (0.22)	0.04 (0.72)	0.1%

TABLE 3

Test of Uncovered Interest Rate Parity

The table reports results for predictive regressions of next month's currency return on the current month's forward currency premium (discount) for each of the 11 currencies against the US dollar. The specification is $s_{t+1} - s_t = \alpha + \beta(f_t - s_t) + \varepsilon_{t+1}$, where spot exchanges rates and forward currency premiums are expressed in logs, i.e., $s_t = \ln(S_t)$, and $\ln(1 + FCP_t) = \ln(F_t) - \ln(S_t) = f_t - s_t$. The table shows the regression intercepts (α), slope coefficients (β), and adjusted R^2 (R^2). T-statistics are reported in parenthesis. The sample period is January 1985 to December 2019.

Currency (Base Currency USD)	α	β	R^2
Australia	0.00 (-1.03)	-0.82 (-1.14)	0.3%
Canada	0.00 (-0.38)	-0.79 (-0.95)	0.2%
Denmark	0.00 (0.66)	-0.66 (-1.04)	0.3%
Germany	0.00 (0.90)	-0.06 (-0.07)	0.0%
Japan	0.00 (1.70)	-1.16 (-1.22)	0.4%
New Zealand	0.00 (-1.08)	-0.99 (-1.95)	1.0%
Norway	0.00 (-0.07)	-0.06 (-0.12)	0.0%
Singapore	0.00 (0.99)	0.33 (0.72)	0.1%
Sweden	0.00 (-0.13)	-0.06 (-0.10)	0.0%
Switzerland	0.00 (1.69)	-0.84 (-0.92)	0.2%
UK	0.00 (-0.66)	-1.11 (-1.42)	0.5%

TABLE 4

Variance Decomposition of Unhedged Foreign Asset Returns

The table shows the standard deviation of unhedged foreign asset returns, $std.dev(R_{i,t+1}^{UH})$, as well as the contribution of the following components to the overall variance of unhedged returns, $var(R_{i,t+1}^{UH})$, (1) the variance of the asset returns in local currency, $var\ (R_{i,t+1}^{a})$, (2) the variance of currency returns, $var\ (R_{i,t+1}^{c})$, (3) the covariance of the asset and currency returns, $cov(R_{i,t+1}^{a}, R_{i,t+1}^{c})$, and (4) higher order terms from the contribution of the cross-product terms to the variance of the asset returns, ΔV_i^{UH}, for equity (Panel A) and fixed income (Panel B) across 11 countries from the perspective of a US investor. The table reports the percentage contribution of components (1) to (4) to the overall variance of unhedged returns. Simple averages of the individual country estimates are shown in the last row of each panel. The sample period is January 1985 to December 2019, except as described in Table 1.

PANEL A: EQUITY

	$std.dev(R_{i,t+1}^{UH})$	$\frac{var(R_{i,t+1}^{a})}{var(R_{i,t+1}^{UH})}$	$\frac{var(R_{i,t+1}^{c})}{var(R_{i,t+1}^{UH})}$	$\frac{(2 * cov(R_{i,t+1}^{a}, R_{j,t+1}^{c}))}{var(R_{i,t+1}^{UH})}$	$\frac{\Delta V_i^{UH}}{var(R_{i,t+1}^{UH})}$
Australia	6.37	49.89%	27.31%	24.14%	-1.34%
Canada	5.37	59.86%	16.10%	24.72%	-0.67%
Denmark	5.64	84.96%	28.31%	-12.52%	-0.75%
Germany	6.57	83.22%	21.73%	-5.70%	0.75%
Japan	6.26	78.30%	30.33%	-10.87%	2.25%
New Zealand	6.39	63.03%	29.29%	11.52%	-3.85%
Norway	7.34	75.17%	17.85%	7.33%	-0.36%
Singapore	7.14	82.42%	4.86%	12.55%	0.17%
Sweden	7.06	83.77%	20.47%	-3.69%	-0.55%
Switzerland	4.94	87.32%	44.80%	-33.93%	1.81%
UK	5.07	72.56%	33.02%	-7.22%	1.64%
Average	6.20	74.59%	24.92%	0.57%	-0.08%

PANEL B: FIXED INCOME

	$std.dev(R_{i,t+1}^{UH})$	$\frac{var(R_{i,t+1}^{a})}{var(R_{i,t+1}^{UH})}$	$\frac{var(R_{i,t+1}^{c})}{var(R_{i,t+1}^{UH})}$	$\frac{(2 * cov(R_{i,t+1}^{a}, R_{j,t+1}^{c}))}{var(R_{i,t+1}^{UH})}$	$\frac{\Delta V_i^{UH}}{var(R_{i,t+1}^{UH})}$
Australia	3.38	4.48%	97.07%	-2.47%	0.93%
Canada	2.28	8.75%	89.59%	1.04%	0.62%
Denmark	2.93	3.56%	104.92%	-16.17%	7.69%
Germany	3.11	2.04%	96.93%	0.05%	0.98%
Japan	3.54	1.32%	94.78%	3.46%	0.45%
New Zealand	3.42	2.32%	102.25%	-1.69%	-2.88%
Norway	3.08	2.65%	101.55%	-3.66%	-0.54%
Singapore	1.66	2.52%	90.28%	4.89%	2.31%
Sweden	3.24	3.12%	97.13%	-8.26%	8.02%
Switzerland	3.40	1.57%	94.77%	2.93%	0.73%
UK	2.98	4.89%	95.48%	-2.01%	1.64%
Average	3.00	3.38%	96.80%	-1.99%	1.81%

TABLE 5

Unhedged and Hedged Portfolios Based on Different Target Allocations to Equity and Fixed Income

The table reports results for unhedged and hedged developed markets portfolios based on different target allocations to equity and fixed income from the perspective of a US investor. The portfolios include Australia, Canada, Denmark, Germany, Japan, New Zealand, Norway, Singapore, Sweden, Switzerland, the UK, and the US, apply market cap weights across countries, and are rebalanced monthly. To be included in the developed markets portfolios, a country must have valid currency returns and local asset returns at the rebalance month. The sample period is January 1985 to December 2019, except as described in Table 1.

EQUITY ALLOCATION/FIXED INCOME ALLOCATION

	80%/20%		60%/40%		40%/60%		20%/80%	
	Unhedged	Hedged	Unhedged	Hedged	Unhedged	Hedged	Unhedged	Hedged
Annualized Std. Dev.	11.97	10.99	9.36	8.25	6.99	5.54	5.16	2.94
Percentage Reduction in Std. Dev. vs. Unhedged		8.14		11.91		20.79		43.03
Monthly Returns								
Minimum	-14.06	-14.64	-10.09	-10.49	-6.26	-6.34	-5.47	-2.28
Maximum	10.20	8.77	8.15	6.82	6.40	5.00	5.58	3.38
12-Month Rolling Returns								
Minimum	-37.42	-33.40	-29.10	-25.24	-20.00	-16.35	-10.06	-6.69
Maximum	57.42	38.31	48.51	31.45	40.00	24.85	31.88	19.16

Past performance is no guarantee of future results. Based on hypothetical results. Filters were applied to data retroactively with the benefit of hindsight. See appendix for more information.

TABLE 6

Selective Hedging

Panel A reports the performance of selectively hedged, statically hedged, unhedged, and hedged developed markets equity and fixed income portfolios from the perspective of a US investor. The selectively hedged strategy hedges the currency exposure in markets where the observed forward currency premium is positive and leaves the currency exposure unhedged otherwise. The statically hedged strategy maintains a hedge ratio equal to the time-series average hedge ratio of the selectively hedged strategy every month for each individual currency. Portfolios are rebalanced monthly and include Australia, Canada, Denmark, Germany, Japan, New Zealand, Norway, Singapore, Sweden, Switzerland, the UK, and the US, where countries are equal weighted. To be included in the developed markets portfolios, a country must have valid currency returns and local asset returns at the rebalance month. The sample period is January 1985 to December 2019, except as described in Table 1. Panel B reports the percentage of months hedged for each currency in selective hedging strategies and is used as the hedge ratio for the static hedging strategy. Differences in percentage of months hedged between equity and fixed income of the same country are due to different return starting months for equity and fixed income series as shown in the appendix.

PANEL A: SUMMARY STATISTICS FOR SELECTIVELY HEDGED EQUITY AND FIXED INCOME PORTFOLIOS (EQUAL WEIGHTED ACROSS COUNTRIES)

	Equity				Fixed Income			
	Selective	Static	Unhedged	Hedged	Selective	Static	Unhedged	Hedged
Average Monthly Return	1.04	0.95	1.01	0.86	0.53	0.44	0.51	0.36
Average Month Return Difference vs. Selectively Hedged	–	-0.09	-0.03	-0.18	–	-0.09	-0.02	-0.17
t-statistics of Difference	–	-3.21	-0.57	-2.85	–	-2.90	-0.39	-0.34
Annualized Compound Return	11.89	10.70	11.30	9.72	6.43	5.35	5.97	4.39
Annualized Compound Return Difference vs. Selectively Hedged	–	-1.20	-0.60	-2.17	–	-1.08	-0.46	-2.04
Annualized Std. Dev.	15.24	15.14	16.31	13.90	4.71	3.88	7.47	1.29

PANEL B: PERCENTAGE OF MONTHS HEDGED

	Equity	Fixed Income
Australia	15.95	15.95
Canada	39.29	39.29
Denmark	54.30	58.27
Germany	69.29	69.29
Japan	92.38	92.38
New Zealand	11.20	13.15
Norway	31.43	41.67
Singapore	74.05	73.31
Sweden	40.00	48.28
Switzerland	87.62	87.62
UK	20.71	20.71
US	–	–

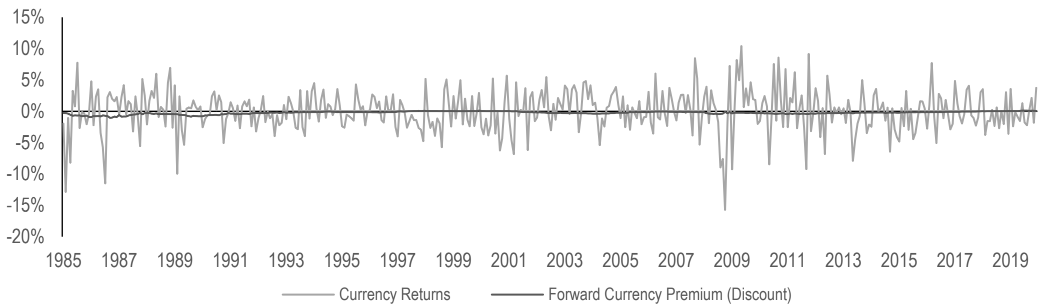
Past performance is no guarantee of future results. Based on hypothetical results. The performance was achieved with the retroactive application of a model designed with the benefit of hindsight. See appendix for more information.

Figures

FIGURE 1

AUD/USD Spot Currency Returns versus Forward Currency Premium (Discount)

The figure shows Australian dollar currency returns and forward currency premium (discount) from the perspective of a US investor. Currency returns are given by $\frac{S_{i,t+1}-S_{i,t}}{S_{i,t}}$, where $S_{i,t}$ is the spot US dollar price of an Australian dollar at time *t*. The forward currency premium (discount) is defined as $\frac{F_{i,t}}{S_{i,t}} - 1$, where $F_{i,t}$, is the one-month forward rate at time *t.* Currency returns are monthly. The sample period is from January 1985 to December 2019.



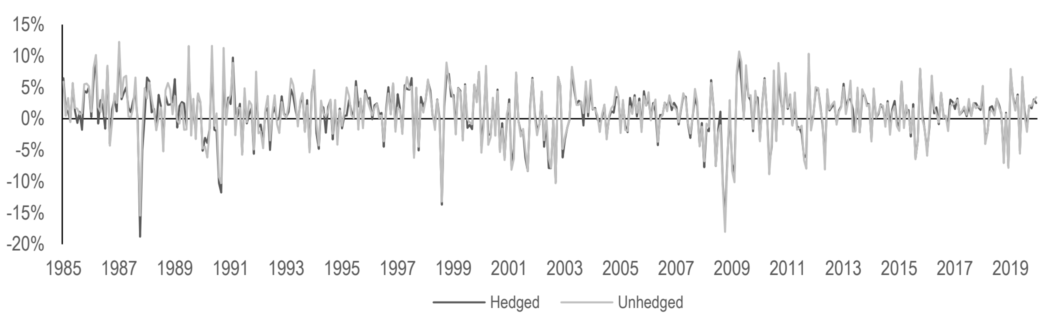
Past performance is no guarantee of future results.

FIGURE 2

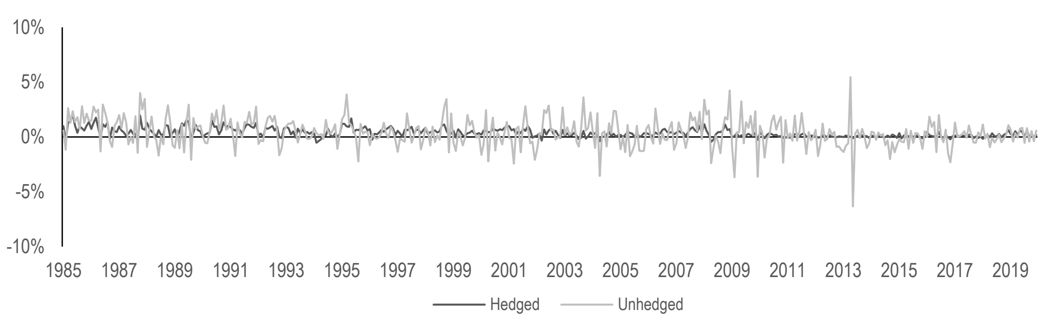
Hedged versus Unhedged Value-Weighted Portfolios

The figure shows the unhedged and hedged returns for a developed markets equity portfolio (Panel A) and a developed markets fixed income portfolio (Panel B) from January 1985 to December 2019 from the perspective of a US investor. The portfolios are rebalanced monthly, and include Australia, Canada, Denmark, Germany, Japan, New Zealand, Norway, Singapore, Sweden, Switzerland, the UK, and the US, where the countries are market cap weighted. To be included in the portfolios, a country must have valid currency returns and local asset returns at the rebalance month. The sample period is from January 1985 to December 2019, except as described in Table 1.

PANEL A: DEVELOPED MARKETS EQUITY



PANEL B: DEVELOPED MARKETS FIXED INCOME



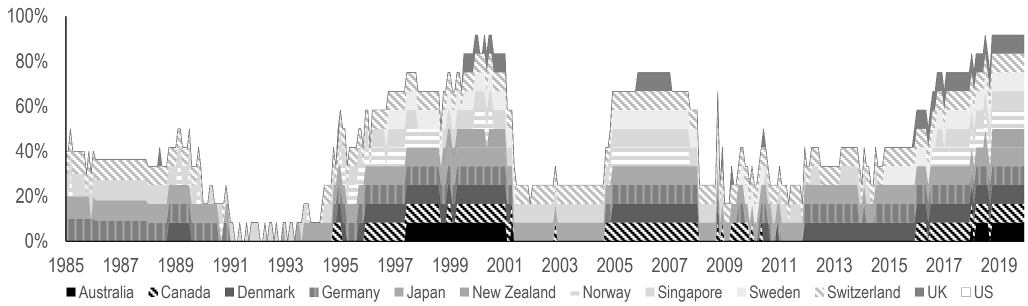
Past performance, including hypothetical performance, is no guarantee of future results. Based on hypothetical results. Filters were applied to data retroactively with the benefit of hindsight. See appendix for more information

FIGURE 3

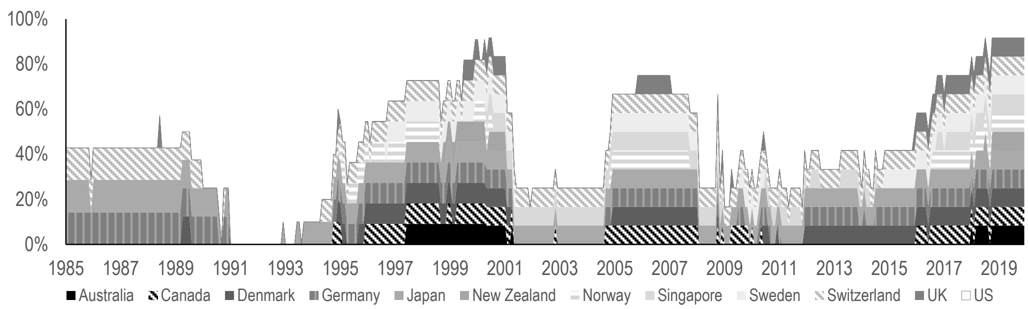
Time Series of Hedged Currencies in Selectively Hedged Portfolios

The figure plots countries hedged in a selectively hedged developed markets equity portfolio (Panel A) and a selectively hedged developed markets fixed income portfolio (Panel B) from January 1985 to December 2019, where countries are equal weighted. Selectively hedged strategies hedge the currency exposure in markets where the observed forward currency premium is positive and leave the currency exposure unhedged otherwise. Portfolios equally weight countries and include Australia, Canada, Denmark, Germany, Japan, New Zealand, Norway, Singapore, Sweden, Switzerland, the UK, and the US. To be included in the developed markets portfolios, a country must have valid currency returns and local asset returns at the rebalance month. The sample period is January 1985 to December 2019, except as described in Table 1.

PANEL A: EQUITY PORTFOLIO



PANEL B: FIXED INCOME PORTFOLIO



Past performance, including hypothetical performance, is no guarantee of future results. Based on hypothetical results. The performance was achieved with the retroactive application of a model designed with the benefit of hindsight. See appendix for more information

Appendix

The sample period for most countries is from January 1985 to December 2019. Due to data availability, not all series begin in January 1985. The table below lists when currency, local equity, and local fixed income returns are available for each country. Currency returns of 11 major currencies against the US dollar using monthly spot exchange rates data from MSCI. Equity returns based on MSCI country indices (gross div.) in each country's local currency. Fixed income returns measured using the country carve-outs of the FTSE Government Bond 1-3 Years Index in each country's local currency.

	Currency	Equity	Fixed Income
Australia	198501	198501	198501
Canada	198501	198501	198501
Denmark	198501	198602	198904
Germany	198501	198501	198501
Japan	198501	198501	198501
New Zealand	198501	198801	199210
Norway	198501	198501	199501
Singapore	198501	198501	200005
Sweden	198501	198501	199101
Switzerland	198501	198501	198501
UK	198501	198501	198501
US	198501	198501	198501

Simulated returns are based on model/backtested performance for research purposes. Hypothetical performance was achieved with the retroactive application of a model designed with the benefit of hindsight. Backtested results are hypothetical and for informational purposes only. The results are not representative of indices, actual investments, or actual strategies managed by Dimensional. Assumes reinvestment of dividends and capital gains. Results do not reflect any costs or fees associated with actual investing. Actual investment returns may be lower or may differ significantly. Data is subject to numerous limitations. Results for different time periods could differ, perhaps significantly, from the results shown. Premiums can be calculated using different methodology. Results could differ, perhaps significantly, when using different methodology. The simulated performance is "gross performance," which includes the reinvestment of dividends and other earnings but does not reflect the deduction of investment advisory fees and other expenses. A client's investment returns will be reduced by the advisory fees and other expenses that may be incurred in the management of the advisory account. For example, if a 1% annual advisory fee were deducted quarterly and a client's annual return were 10% (based on quarterly returns of approximately 2.41% each) before deduction of advisory fees, the deduction of advisory fees would result in an annual return of approximately 8.91% due, in part, to the compound effect of such fees. Dimensional's advisory fees are described in Part 2A of Dimensional's Form ADV Part 2A. Past performance, including simulated performance, is no guarantee of future results.

References

Barroso, Pedro, and Pedro Santa-Clara. 2015. "Beyond the Carry Trade: Optimal Currency Portfolios." *Journal of Financial and Quantitative Analysis* 50, no. 5: 1037–1056.

Black, Fischer. 1990. "Equilibrium Exchange Rate Hedging." *The Journal of Finance* 45, no. 3: 899–907.

Burnside, Craig, Martin Eichenbaum, Isaac Kleshchelski, and Sergio Rebelo. 2010. "Do Peso Problems Explain the Returns to the Carry Trade?" *The Review of Financial Studies* 24, no. 3: 853–891.

Calomiris, Charles W., and Harry Mamaysky. 2019. "Monetary Policy and Exchange Rate Returns: Time-Varying Risk Regimes." No. w25714. National Bureau of Economic Research.

Campbell, John Y., Karine Serfaty-De Medeiros, and Luis M. Viceira. 2010. "Global Currency Hedging." *The Journal of Finance* 65, no. 1: 87–121.

Cheung, Yin-Wong, Menzie D. Chinn, and Antonio Garcia Pascual. 2005. "Empirical Exchange Rate Models of the Nineties: Are Any Fit to Survive?" *Journal of International Money and Finance* 24, no. 7: 1150–1175.

Chinn, Menzie D., and Saad Quayyum. 2012. "Long Horizon Uncovered Interest Parity Re-assessed." No. w18482. National Bureau of Economic Research.

Daniel, Kent, Robert J. Hodrick, and Zhongjin Lu. 2014. The Carry Trade: Risks and Drawdowns. No. w20433. National Bureau of Economic Research.

Fama, Eugene F. 1984. "Forward and Spot Exchange Rates." *Journal of Monetary Economics* 14, no. 3: 319–338.

Glen, Jack, and Philippe Jorion. 1993. "Currency Hedging for International Portfolios." *The Journal of Finance* 48, no. 5: 1865–1886.

Ismailov, Adilzhan, and Barbara Rossi. 2018. "Uncertainty and deviations from uncovered interest rate parity." *Journal of International Money and Finance* 88: 242–259.

Jurek, Jakub W. 2014. "Crash-neutral Currency Carry Trades." *Journal of Financial Economics* 113, no. 3: 325–347.

Lustig, Hanno, Nikolai Roussanov, and Adrien Verdelhan. 2011. "Common Risk Factors in Currency Markets." *The Review of Financial Studies* 24, no. 11: 3731–3777.

Meese, Richard A., and Kenneth Rogoff. 1983. "Empirical Exchange Rate Models of the Seventies: Do They Fit Out of Sample?" *Journal of International Economics* 14, no. 1–2: 3–24.

Ranaldo, Angelo, and Paul Söderlind. 2010. "Safe Haven Currencies." *Review of Finance* 14, no. 3: 385–407.

Rogoff, Kenneth, 2009. "Exchange Rates in the Modern Floating Era: What Do We Really Know? *Review of World Economics*, 145(1), pp.1–12

Rogoff, Kenneth S., and Vania Stavrakeva. 2008. "The Continuing Puzzle of Short Horizon Exchange Rate Forecasting. No. w14071. National Bureau of Economic Research.

Rossi, Barbara. 2013. "Exchange Rate Predictability." *Journal of Economic Literature*, 51 (4): 1063–1119.

Taylor, Mark P. "The Economics of Exchange Rates." *Journal of Economic Literature* 33, no. 1 (1995): 13–47.

Disclosures

For Professional Use Only. Not for use with Retail Investors or the Public.

The information in this material is intended for the recipient's background information and use only. It is provided in good faith and without any warranty or, representation as to accuracy or completeness. Information and opinions presented in this material have been obtained or derived from sources believed by Dimensional to be reliable and Dimensional has reasonable grounds to believe that all factual information herein is true as at the date of this document. It does not constitute investment advice, recommendation, or an offer of any services or products for sale and is not intended to provide a sufficient basis on which to make an investment decision. It is the responsibility of any persons wishing to make a purchase to inform themselves of and observe all applicable laws and regulations. Unauthorized reproduction or transmitting of this material is strictly prohibited. Dimensional accepts no responsibility for loss arising from the use of the information contained herein. All figures contained within the material are in USD.

"Dimensional" refers to the Dimensional separate but affiliated entities generally, rather than to one particular entity. These entities are Dimensional Fund Advisors LP, Dimensional Fund Advisors Ltd., Dimensional Ireland Limited, DFA Australia Limited, Dimensional Fund Advisors Canada ULC, Dimensional Fund Advisors Pte. Ltd, Dimensional Japan Ltd., and Dimensional Hong Kong Limited. Dimensional Hong Kong Limited is licensed by the Securities and Futures Commission to conduct Type 1 (dealing in securities) regulated activities only and does not provide asset management services.

Eugene Fama and Ken French are members of the Board of Directors of the general partner of, and provide consulting services to, Dimensional Fund Advisors LP.

The following persons are employees of Dimensional Investment LLC, a subsidiary of Dimensional Fund Advisors LP: Marlena Lee, Savina Rizova, Wei Dai, Warwick Schneller.

United States

This information is provided for registered investment advisors and institutional investors and is not intended for public use. Dimensional Fund Advisors LP is an investment advisor registered with the Securities and Exchange Commission.

Canada

This document is issued by Dimensional Fund Advisors Canada ULC for registered investment advisors, dealers, and institutional investors and is not intended for public use. Commissions, trailing commissions, management fees, and expenses all may be associated with mutual fund investments. Please read the prospectus before investing. Unless otherwise noted, any indicated total rates of return reflect the historical annual compounded total returns including changes in share or unit value and reinvestment of all dividends or other distributions and do not take into account sales, redemption, distribution, or optional charges or income taxes payable by any security holder that would have reduced returns. Mutual funds are not guaranteed, their values change frequently, and past performance may not be repeated. The other Dimensional entities referenced herein are not registered resident investment fund managers or portfolio managers in Canada.

Australia

In Australia, this material is provided by DFA Australia Limited (AFSL 238093, ABN 46 065 937 671). It is provided for financial advisors and wholesale investors for information only and is not intended for public use. No account has been taken of the objectives, financial situation or needs of any particular person. Accordingly, to the extent this material constitutes general financial product advice, investors should, before acting on the advice, consider the appropriateness of the advice, having regard to the investor's objectives, financial situation and needs. Any opinions expressed in this publication reflect our judgment at the date of publication and are subject to change.

New Zealand

This publication is provided in New Zealand by DFA Australia Limited, (AFS Licence No.238093, ABN 46 065 937 671).

This publication is provided for financial advisers only and is not intended for public use. All material that Dimensional provides has been prepared for advisers, institutional investors and clients who are classified as Wholesale investors under the Financial Markets Conduct Act 2013.

Where Issued by Dimensional Ireland Limited

Issued by Dimensional Ireland Limited (DIL), with registered office 10 Earlsfort Terrace, Dublin 2, D02 T380, Ireland. DIL is regulated by the Central Bank of Ireland (Registration No. C185067). Directed only at professional clients within the meaning of Markets in Financial Instruments Directive (MiFID) (2014/65/EU). Information and opinions presented in this material have been obtained or derived from sources believed by DIL to be reliable, and DIL has reasonable grounds to believe that all factual information herein is true as at the date of this document.

DIL issues information and materials in English and may also issue information and materials in certain other languages. The recipient's continued acceptance of information and materials from DIL will constitute the recipient's consent to be provided with such information and materials, where relevant, in more than one language.

Where Issued by Dimensional Fund Advisors Ltd.

Issued by Dimensional Fund Advisors Ltd. (DFAL), 20 Triton Street, Regent's Place, London, NW1 3BF. DFAL is authorised and regulated by the Financial Conduct Authority (FCA). Directed only at professional clients as defined by the rules of the FCA. Information and opinions presented in this material have been obtained or derived from sources believed by DFAL to be reliable, and DFAL has reasonable grounds to believe that all factual information herein is true as at the date of this document.

DFAL issues information and materials in English and may also issue information and materials in certain other languages. The recipient's continued acceptance of information and materials from DFAL will constitute the recipient's consent to be provided with such information and materials, where relevant, in more than one language.

Notice to Investors in Switzerland: This is an advertising document.

Risks

Investments involve risks. The investment return and principal value of an investment may fluctuate so that an investor's shares, when redeemed, may be worth more or less than their original value. Past performance is not a guarantee of future results. There is no guarantee strategies will be successful.

Japan

Provided for institutional investors only. This document is deemed to be issued by Dimensional Japan Ltd., which is regulated by the Financial Services Agency of Japan and is registered as a Financial Instruments Firm conducting Investment Management Business and Investment Advisory and Agency Business. This material is solely for informational purposes only and shall not constitute an offer to sell or the solicitation to buy securities or enter into investment advisory contracts. The material and any content contained herein may not be reproduced, copied, modified, transferred, disclosed, or used in any way not expressly permitted by Dimensional Japan Ltd. in writing. All expressions of opinion are subject to change without notice.

Dimensional Japan Ltd.
Director of Kanto Local Financial Bureau (FIBO) No. 2683
Membership: Japan Investment Advisers Association

For Licensed or Exempt Financial Advisors and Institutional Investors in Singapore

This document is deemed to be issued by Dimensional Fund Advisors Pte. Ltd., which is regulated by the Monetary Authority of Singapore and holds a capital markets services license for fund management.

This document is not an advertisement, has not been reviewed by the Monetary Authority of Singapore, and should not be shown to prospective retail investors. For use by institutional investors and licensed or exempt financial advisors only in Singapore for internal training and educational purposes and not for the purpose of inducing, or attempting to induce, such institutional investors or financial advisors to make an investment. Not for use with the public.

This information should not be considered investment advice or an offer of any security for sale. All information is given in good faith without any warranty and is not intended to provide professional, investment, or any other type of advice or recommendation and does not take into account the particular investment objectives, financial situation, or needs of individual recipients. Before acting on any information in this document, you should consider whether it is suitable for your particular circumstances and, if appropriate, seek professional advice. Dimensional Fund Advisors Pte. Ltd.

does not accept any responsibility and cannot be held liable for any person's use of or reliance on the information and opinions contained herein. Neither Dimensional Fund Advisors Pte. Ltd. nor its affiliates shall be responsible or held responsible for any content prepared by institutional investors or financial advisors.

For Licensed Financial Advisors and Institutional Investors in Hong Kong

This document is deemed to be issued by Dimensional Hong Kong Limited (CE No. BJE760), which is licensed by the Securities and Futures Commission to conduct Type 1 (dealing in securities) regulated activities only and does not provide asset management services.

For use by licensed financial advisors and institutional investors who are "professional investors" (as defined in the Securities and Futures Ordinance [Chapter 571 of the Laws of Hong Kong] and its subsidiary legislation) only in Hong Kong. This document is provided solely for internal training and educational purposes and is not for the purpose of inducing, or attempting to induce, such financial advisors and institutional investors to make an investment nor for the purpose of providing investment advice. Not for use with the public.

Unauthorized copying, reproducing, duplicating, or transmitting of this document are prohibited. This document and the distribution of this document are not intended to constitute and do not constitute an offer or an invitation to offer to the Hong Kong public to acquire, dispose of, subscribe for, or underwrite any securities, structured products, or related financial products or instruments nor investment advice thereto. Any opinions and views expressed herein are subject to change. Neither Dimensional Hong Kong Limited nor its affiliates shall be responsible or held responsible for any content prepared by financial advisors or institutional investors. Financial advisors in Hong Kong shall not actively market the services of Dimensional Hong Kong Limited or its affiliates to the Hong Kong public.