The Hedging of Currency Risk for U.S. Equity Investors

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International investing has increased in popularity and currency risk is an important component in the investing decision. Despite this, there is little definitive guidance for equity investors as to how to hedge currency risk. Some advocate a full currency hedge, arguing that, since the expected return for currencies is zero, removing risk results in a free lunch. In practice, the degree to which currency risk should be hedged depends partly on the correlation between the currency and stock returns. This correlation varies substantially within and between developed and emerging markets, and depends on an economy's characteristics. We use a simple, easily implemented ex-ante risk minimizing hedge ratio and show that it often has stronger performance than a full hedge or other heuristic hedge ratios, especially in developed markets.

1. Introduction

When investing in a foreign asset, an investor undertakes two positions; in the foreign asset itself as well as the foreign currency. In the case of a fixed income investor with relatively high risk-aversion, the currency hedging decision is relatively straightforward; hedging will substantially reduce investment risk because currency risk is typically twice that of bond risk.[1] However, equity risk is typically twice that of currency risk, so hedging currency risk might not substantially reduce the risk of a foreign equity position.

International diversification has increased in popularity. Philips et. al. (2012) report that home country investing bias has dropped by 10% or more in four developed markets (DMs) from 2001 to 2012. As equity investors move more of their assets abroad, currency exposure increases and the decision as to whether to hedge currency exposure becomes more important.

The risk of investing in foreign equity is dependent on the risk of the local currency and equity as well as the correlation between the equity and the currency.[2] Consequently, the currency hedging decision for equity investments becomes more complicated. Whether currency risk should be hedged is debated amongst practitioners and academics. Schurter (2009) finds that hedging currency risk does not significantly impact a US investor's total portfolio risk or return. Similarly, LeGraw (2015) argues that currency risk for a portfolio of global stocks is reduced by the heterogeneity of the firms' positions, e.g., an exporter's currency exposure will be offset to some degree by an importer's exposure. Secondly, although most multinationals are headquartered in a single country, the firm itself is largely unaffected by the domestic currency due to its global nature.[3] Third, due to increased global trade and the resulting diversification of firm currency exposures, the currency risk component of a global equity portfolio has decreased over time. In the end, she argues that hedging currency risk can actually increase portfolio volatility. From Bartram et. al. (2010), many firms do not exhibit sizable foreign currency exposure due to operational hedges, derivatives usage, and the pass-through of currency risk to

[1] See Boudoukh, Katz, Richardson, & Thapar (2015) among others.
[2] Chen et. al. (2015), argue that while many use the correlation between the currency in domestic currency terms and the equity in local currency, the relevant correlation from the investor's perspective to use is that between the foreign currency and the equity, both in the investor's domestic currency.
[3] She gives the example of the UK, where about half the equity market capitalization is represented by firms with less than 10% of revenue from the UK.

customers. As such, if investors short the firm's currency, they will have actually created a naked short position in the currency.

Other practitioners, however, argue that hedging currency risk should be considered. Schwartz and Gannatti (2014) note that a forward position can actually increase an investor's income and that markets outside the US have had favorable performance when their currencies were weak. LaBarge et. al. (2014) state that hedging is very inexpensive and that foreign currency exposure often entails substantial risk.

From an academic perspective, other authors argue that currencies are not an asset class. That is, there is no inherent reason why currencies should provide a risk premium, and therefore investors should avoid currency risk. Boudoukh, Katz, Richardson, & Thapar (2015) advise that an investor should generally hedge currency risk because currencies typically have zero expected return and non-zero volatility, i.e., there is no return reward for the risk taken on. In their framework, an unhedged position is only attractive when the correlation between foreign equities and currencies is persistently, highly negative, which they do not find evidence of using a global equity portfolio. However, the data used are for a broad global equity portfolio and does not evaluate particular currencies, countries, or sectors.

Consistent with Boudoukh et. al. (2015), the empirical results from Perold and Schulman (1988) show near zero currency returns, on average. They thus conclude that hedging currency risk is a free lunch, as risk is eliminated without loss of expected return. Shead (2008) also finds results consistent with a free lunch.

Alternatively, some view currencies as a separate asset class, whereby the astute investor can capture profits using the carry trade, i.e., borrowing at a low interest rate and investing in another higher interest rate. Contrary to the free lunch argument of Perold and Schulman, Chang (2009) reports results that are consistent with the risk-return tradeoff, where lower risk (hedged) portfolios earn lower returns. Campbell, Serfaty-de Medeiros, and Viceira (2010) find that hedging benefits vary by market invested in, where US equity investors should pursue partial-, full-, or even over-hedging of currency risk.

The covered (uncovered) interest rate parity condition states that the forward rate (exchange rate changes) will reflect nominal interest rate differences between two countries.

Combining the two parity conditions results in forward rate parity, where the forward rate is an unbiased estimator of the future spot rate.

If forward rate parity holds, then, on average, the returns from an unhedged position will result in the same returns as that from hedging currency risk using forward contracts. On the other hand, if forward rate parity does not hold, then the mean returns to hedged and unhedged positions will differ. In fact, forward rate bias has been found in many currency pairs.[4] Forward rate bias states that higher yielding currencies trading at a forward discount will, on average, actually appreciate. If forward rate bias is more prevalent than forward rate parity, then unhedged positions in higher yielding currencies will result in higher returns, relative to that for hedged positions. It is typically the case that emerging markets (EMs) offer higher yields than developed markets (DMs).

For a sample of DMs, Schmittmann (2010) finds that hedged returns are generally not statistically significantly different than unhedged returns. He does however find meaningfully different economic returns, with hedged equity returns typically higher than unhedged returns. Differences in risk are however statistically and economically significant, with optimal hedge ratios (OHRs) often different than 100% (a full hedge). However, his study is limited to four developed market currencies. Evidence to the contrary is provided by Morey and Simpson (2001) and Simpson (2004) who found that the performance of unhedged strategies is superior to the performance of hedged strategies.

Another consideration in the hedging decision are mean reversion patterns. Over long periods of time, many developed market currencies have mean reversion patterns, whereby depreciating currencies eventually appreciate, and vice versa. For long investment horizons, Froot (1993) argues that due to their mean reverting behavior, currencies should not be hedged because hedging increases risk for horizons of more than five years. On the other hand, investors with shorter investment horizons may not have the luxury of waiting for potential mean reversion.

A third consideration in the hedging decision is the correlation between the foreign stock return and the foreign currency. In developed countries, currencies and stock returns may be

[4] There is a FTSE Currency Forward Rate Bias (FRB) Index Series designed to capture this occurrence.

negatively correlated if a depreciating currency makes the country's exports less expensive to foreign consumers, such that when currencies depreciate, exporters' earnings and stock prices might increase. By doing so, currency and stock movements often offset one another to some degree, reducing the risk to a foreign investor. The more negative the correlation, the lower the risk of an unhedged portfolio. In this case, hedging currency risk would remove the natural hedge provided and potentially result in higher risk, relative to an unhedged portfolio. Cho et. al. (2016) examines a sample of Korean ''Siamese Twin'' fund pairs that differ only as to whether currency risk is hedged. Hedged portfolios are found to have higher volatility than their non-hedged twin, because hedging undoes the negative correlation between the foreign currency and the underlying assets.

Whether a currency should be hedged depends in part on the corresponding economy's focus. The correlation between the foreign currency and the equity may vary for export versus import-oriented economies. For exporters, if their currency depreciates, this potentially benefits the firm, as the value of their exports increases and/or the firm increases exports. In this scenario, the currency and equity move opposite one another, and the investor's currency exposure is dampened. For importers, a depreciating currency hurts the firm, as their imports become more expensive in their currency. In this scenario, the currency and equity move together and risk is accentuated.[5] Similarly, for commodity-oriented economies, the USD is known to have a negative correlation with commodity prices. A strong dollar, aka weak foreign currency, is associated with falling commodity prices. As a result, economies dependent on commodities may have currencies positively correlated with stock prices.

The correlation between the currency and equity value is also thought to differ by developed versus emerging markets. In developed countries with an exporting focus, the correlation is often negative. Hau and Rey (2006) find that a negative correlation is more likely to occur in DMs. In EMs however, the correlation is frequently positive. This may be because many EMs depend heavily on commodity exports. Another reason is that often during crisis periods, both emerging currencies and stocks decline in value as investors lose faith in emerging countries. A third reason is that, for emerging firms with debt denominated in dollars, a weaker

[5] See Pritamani, Shome, and Singal (2005) for a comparison of currency risk for importers versus exporters.

domestic currency makes repayment of the debt more expensive.[6] In these cases where the correlation was positive, the emerging market stockholder could experience losses on both the stock and currency position and a full hedge would be recommended.

Whereas previous academic research argues that currency risk should be fully hedged because currencies have zero expected return, we examine the actual risk and return from both hedged and unhedged positions, the latter of which reflects the global nature of firms and their natural and financial hedges, for a much broader cross-section of developed and emerging countries than in previous studies. We hypothesize that unhedged portfolios may sometimes have lower risk than hedged portfolios and/or possibly higher returns. Furthermore, whereas much of previous research examined the hedging question using static hedges and/or globally diversified portfolios, we allow for a dynamic hedge in individual country equity portfolios. Our methodology allows for the economic orientation of individual countries (e.g., importing versus exporting) and each currency's historical and recent strength. Whereas some currencies have tended to be historically strong (e.g., the Swiss franc), others (e.g., emerging market currencies) have tended to be weak. Furthermore, previous research has found that currencies can exhibit momentum patterns.[7]

[6] See Chue and Cook (2008).
[7] e.g., Asness, Moskowitz, and Pedersen (2013).

2. Methodology

The optimal hedge ratio (OHR) has been debated over time. Black (1990) argues for a universal hedge ratio of 0.75 whereas Gastineau (1995) advocates for 0.50. Practitioners will sometimes choose 0.50 to prevent the potential regret from fully hedging or not hedging at all.[8] Schurter (2009) reports that 69% of institutional investors do not hedge currency risk, and that 91% use simple hedge ratios of 0, 0.50, or 1.00. However, Anson (2014)[9] suggests that such static hedges virtually guarantee the investor will experience regret and Chen et. al. (2015) argue that the OHR varies by currency. Likewise, Glen and Jorion (1993) and Campbell et al. (2010) argue against Black's universal hedge ratio using empirical evidence. Their OHRs vary substantially across currency pairs. Accordingly, we use hedge ratios that vary by currency, allowing for a more specific, dynamic hedge ratio recommendation.

Some authors argue that an optimal hedging ratio cannot be determined ex ante given its time variation and idiosyncratic firm characteristics.[10] Gardner Stone (1995) state that due to estimation error, the determination of an OHR is not a useful endeavor. However, it may be the case that the hedging ratio is relatively consistent over time for particular markets. If so, then the determination of OHRs is not a futile exercise. We therefore examine the OHR, for various investments over various periods to determine its stability over time. This will provide evidence regarding the prevalence of free lunches from hedging versus risk-return tradeoffs from hedging. To address the consistency issue, we estimate confidence intervals for our OHRs.

As in Kim (2012), we calculate an ex post or empirical OHR and compare its performance to that of an unhedged and fully hedged portfolio. We constrain hedge ratios between zero and one as in Kim, who argues that this reflects most investors' hedging positions, and as in Anson (2014) who argues that overhedging (hedge ratios more than one) are impractical because institutions will view that as an active bet that needs monitoring.

We calculate a monthly rolling OHR based on the previous 3 years of data. This provides an ex ante OHR that is then compared to the ex post OHR to determine whether the ex-ante OHR results in significantly different performance, relative to ex post hedging and simplistic 0, 0.50,

[8] See Statman (2005).
[9] Anson (2014).
[10] e.g., Haefliger et. al. (2002).

or 1.00 ratios. If the ratios do not differ in performance, then practitioners may feel more comfortable with static hedges. We also examine whether the performance differences are significant for various hedging strategies.

We examine the OHR for 11 DMs and 13 EMs, including the five largest DMs outside the US: Japan, France, Canada, the UK, and Germany.[11] This provides an interesting sample in several ways. First, the economies are diverse, e.g., Japan (a finished good exporter), the UK (a large financial sector), and Canada (a commodity producer that is closely linked to the US). Second, although France and Germany share a common currency, France is less reliant on manufacturing exports and its OHR may be quite different. These two countries also have the largest economies in the EU. The remaining DM's are also quite diverse: for example, the economies of Australia and Norway rely heavily on commodity exports, while Switzerland is a major financial center. Among the EM's we examine, Brazil, Chile, Indonesia and Peru are heavily reliant on commodity exports, while the other countries have more balanced economies relying on a mix of commodity and manufacturing exports, and services such as tourism.[12]

3. Data

The country stock indices, spot and 1-month forward exchange rates used in the study are sampled on the last trading day of each month and sourced from Datastream. The data for all DM countries begin in January 1988 and extends through December 2019. For the EM countries the starting month is later, ranging from March 1990 (Greece) to July 1997 (Chile).

4. Results

[11] Source: World Bank.

[12] According to the United Nations Conference on Trade and Development (2021) State of Commodity Dependence report, commodity exports as a percentage of total merchandise exports are 66.6% in Brazil, 87.0% in Chile, 55.6% in Indonesia and 90.5% in Peru. These countries, along with Greece (61.3%) have by far the greatest commodity dependence among all of the EMs in our study. However, we are hesitant to include Greece among the primarily commodity-exporting countries because Greece also has a particularly large tourism sector that is not included in its merchandise exports.

4.1 Risk and return for local currency and unhedged USD returns

Table 1 provides the returns and risk for the US and our sample of 24 non-US markets, of which 11 are DMs and 13 are EMs. In the first column of data, equity returns in the LC are followed by the returns for currencies, followed by the unhedged equity returns in the USD for each country. The t-statistics in the last row is for the equality of the LC and unhedged USD returns.

Comparing LC returns for the DMs to that for the US, all had lower returns than that of the US's 0.76% over our 1988-2019 sample period. In the EMs however, 9 of the 13 have higher LC returns, albeit the sample periods, as noted for each country in Table 1, are somewhat shorter for these countries. In USD terms, the returns for non-US DMs range from 0.21% for Japan to 0.74% for Norway, with again all the DM returns being lower than that for the US. In EMs, the picture again differs, with 9 of the 13 EMs having higher USD returns than that in the US. At the extreme, the USD return for Turkey is 1.27%, despite the Turkish lira depreciating by on average 1.46%.

Examining currency returns, about half (5 of 11) DMs experience a reduction in return when moving from LC to USD returns. These results indicate that the return from the currency is positive for about half the DMs and negative for the other half, and none of the LC and USD returns are significantly different.

However, in EMs, the realized currency returns are quite different from DMs as 11 of 13 markets experience a negative currency return. Furthermore, the magnitude of the currency return is substantially larger in EMs, relative to DMs. In only one DM, Switzerland, is the currency return greater than 1% annually at 1.44% (0.12% ×12). In nine EMs, the absolute magnitude of the currency return exceeds 1% annually, with two extreme cases being Mexico at -5.6% (-0.47% × 12) and Turkey at a remarkable -17.5% (-1.46% × 12). Seven other EMs have currency losses greater than -2% annually.

In sum, the returns for all DMs are less than that in the US and currency returns are mixed. In the majority of EMs however, LC as well as USD returns are higher than that in the US, and currency losses are frequent. This implies that an investor should investigate the possibility of hedging currency positions, particularly for EMs, which we explore in subsequent

tables. Additionally, despite the prevalence of currency losses, none of the DMs and only two of the EMs, have LC and USD returns that are statistically significantly different. The lack of significance, especially in EMs, is potentially indicative of substantial variation in equity and currency returns, which we discuss next.

In contrast to returns, there is a greater frequency of significant differences in LC and USD risk as shown in the second column of data. In four DMs and nine EMs, the standard deviation of USD returns is significantly higher than it is for LC returns, and in all 24 markets, standard deviation is greater in USD terms than in LC terms, pointing out the need to consider currency risk when investing abroad. There is also substantial variation in risk when comparing DMs to EMs. In most (9 of 11) DMs, equity return risk in USD is less than 6% whereas 7 of 13 EMs have USD risk greater than 10%. There is also substantial variation in risk within EMs, as the standard deviation of USD returns is lowest for Chile at 6.95% whereas it is highest for Turkey at 13.99%. The higher risk of returns when converted to USD and the variation in risk across markets suggests that investors should consider hedging currency risk and do so by evaluating each market individually.

The currency hedging decision depends upon many factors, including the correlation of currency movements with equity returns in LC terms. If the correlation is less than one, the movements in these two USD return components will offset to some degree. Ideally for the risk-averse investor, the correlation would be negative, such that the two components will move opposite one another, resulting in an even greater reduction in USD risk. In the third column of data in Table 1, negative correlations are prevalent in DMs, with 8 of 11 having negative correlations. In six of these markets, the correlation is significantly different from zero. In three DMs however, the correlation is significantly different from zero and positive; interestingly, these countries are all heavily reliant on commodity exports. However, even the highest correlation in Australia at 0.320 is still rather low, indicating that risk reduction may be available from the relationship between currency and equity returns. As discussed previously, these correlations tend to be positive in EMs and the findings in Table 1 support this as 12 of 13 EMs have significantly positive correlations. As with the positive correlations in DMs however, the only EM with a correlation greater than 0.4 is India, which again indicates the potential for risk reduction.

The relationship between the correlations and investor USD risk is instructive. In the three DMs, when the correlation is significantly positive, the standard deviation in USD terms is significantly greater than the LC risk. In the six DMs where the correlation is significantly negative, the USD and LC risk is not significantly different in five of those markets. Similarly, in 10 of the 12 EMs when the correlation is significantly positive, the USD and LC returns are significantly different. This implies that the correlation should be an important factor in the investor's hedging decision, such that hedging would be less likely when the correlation is negative. Furthermore, for the EMs, the USD risk was usually higher than in DMs and correlations were almost always positive, as opposed to DMs where the correlations were usually negative. The higher risk and different correlations in EMs argue for a hedging decision that is specific to the market invested in.

When moving from LC to USD returns, there was an increase in the standard deviation in all 24 markets. This marginal risk is referred to as the contribution of currency risk (COCR), which depends on the absolute level of currency risk and the correlation between the equity and currency returns. All else being equal, a negative correlation would result in a lower COCR to a USD investor than would a positive correlation. In the fourth column of data in Table 1, we provide the COCR in absolute terms, as a percent of the currency standard deviation, and as a percent of USD equity risk.

Examining the COCR as a percent of the currency and USD equity standard deviations, for the six DMs where the correlation is significantly negative, the COCR is never more than 17% of the currency standard deviation and never more than 11% of the USD equity standard deviation. In contrast, when the correlation is significantly positive in the three DMs, the COCR as a percent of currency risk ranges from 35% to 58%, and as a percent of USD equity risk ranges from 14% to 32%. However, even with the positive correlations in the three DMs, the COCR is never more than two-thirds of currency risk and one-third of USD equity risk. This is also true for the EMs where all correlations were positive and 12 of 13 were significantly so. Thus, although many investors perceive currency risk to be an impediment to investing abroad, especially in EMs, the magnitude of the marginal currency risk as measured by the COCR is not onerous, especially when compared to equity risk. As such, investors in EMs, who likely have higher risk tolerance, may not routinely fully hedge currency risk, given its relative size.

In sum, the evidence in Table 1 indicates that standard deviations, correlations, and the resulting COCRs vary substantially within and between DM and EM classifications. Although all DMs had lower returns than the US market during this time period, many EMs had higher returns, with the COCR never being more than one-third of equity risk. It is surprising how low the marginal contribution to risk from currencies is. Altogether, the evidence suggests that investors should evaluate the correlations described above in each market and pursue a non-heuristic hedging program tailored for the particular market invested in. This is what we do in section 4.3 below.

4.2 Risk and return of unhedged and fully hedged USD returns

In Table 2, we examine the risk and returns for two heuristic strategies that convert LC returns to USD returns using end of month spot rates (completely unhedged, HR0) and using one-month forward rates prevailing at the end of the previous month (fully hedged, HR1). Note that the risk and returns for the HR0 positions repeat that of unhedged positions in Table 1, but are repeated here for convenience. Looking at returns, hedging often reduces return but sometimes increases return. Specifically, in 8 of 11 DMs, hedging reduces return, in three cases the reduction is greater than 1% annually.[13] However, in three DMs, hedging increases return, with the increase being 1.44% annually (-0.12% × 12) in Japan. In 7 of 13 EMs, hedging reduces return, with two reductions being statistically significant, and six decreases being greater than 1% annually. Interestingly, in 6 of 13 EMs, hedging actually increases return, with five increases being statistically significant, and six increases being greater than 1% annually. This result would be surprising to investors who think of hedging as only being useful to reduce risk, not as a return enhancer. Regarding forward rate bias, it would predict that in the high-yielding EMs, unhedged returns are higher than that for hedged returns. For our EMs, the results are mixed, as for about half EM, hedging reduces return (i.e., supporting FRB), with hedging increasing return for the other EMs.

Examining risk, hedging reduces the standard deviation of returns in almost all 24 markets, with the exception being Turkey. The risk reduction is statistically significant in 4 of 11 DMs and 8 of 13 EMs. For the DMs in Table 1 where the correlation between the currency and

[13] e.g., in Canada, hedging reduces return by 0.12% × 12 = 1.44% annually.

equity return is positive, hedging significantly reduces risk in Table 2 for all three. For the 12 EMs where the correlation was significantly positive, hedging reduces risk significantly in eight markets. In contrast, when the correlation is negative,[14] hedging does not reduce risk significantly in 5 of those 6 DMs. This confirms that a negative correlation provides a "built-in" diversifier that should be considered in the hedging decision.

We also examine higher moments of risk in Table 2. For DMs, for both unhedged and hedged returns, returns are always negatively skewed except for unhedged returns in Japan. Hedging reduces the magnitude of negative skewness in 4 of 11 DMs. For EMs, returns are positively skewed except in the case of unhedged Brazilian returns, hedged Turkish returns, and hedged and unhedged returns for Chile and Mexico.[15] In the 6 of the 11 EMs that have positive unhedged skew, hedging reduces positive skew, although in some cases the change is minimal. Positive skewness is generally thought to be favored by investors because it implies the chance for a large return.[16]

Kurtosis is greater than 3.0 for all DMs, except for hedged Australian returns. Hedging reduces kurtosis in 7 of 11 DMs. Using the Jarque-Bera statistic, DM returns are always non-normal except for hedged Australian returns and the statistic is reduced by hedging in 6 of 11 countries. For EMs, kurtosis is greater than 3.0 in all hedged and unhedged returns, and kurtosis and the Jarque-Bera statistic are reduced by hedging for 6 of the 13 markets.

In sum, the results in Table 2 indicate that hedging can actually increase returns, with the increase being economically and statistically significant in several EMs. Hedging is beneficial for risk reduction when the correlation is significantly positive, both in DMs and most EMs. However, hedging usually does not significantly reduce risk when correlations between currency and equity returns are negative. Furthermore, the hedging decision impacts both the skewness and kurtosis of returns.

4.3 Minimum variance dynamic hedging

[14] These markets are France, Germany, Japan, the Netherlands, Switzerland, and the UK.
[15] Our results are consistent with You and Daigler (2010) who report that lower risk portfolios often have negative skewness.
[16] For arguments to the contrary, see Ilmanen, p. 389.

The free-lunch proponents of hedging advocate a full hedge while others argue for no hedge given the tendency of some currencies to mean revert over time. In addition to these polar positions, many practitioners a hedge ratio of 50%, which does not fully hedge currency risk but does reduce the potential regret from full hedging a currency which subsequently appreciates. A fourth perspective is provided by previous research, which determines the optimal currency hedge ratio over an entire period using an ex-post strategy.

We also consider a fifth strategy, which uses the past 36 months of a currency's returns to determine the hedge ratio each month. This ex-ante strategy incorporates information from the currency's risk as well as its correlation with LC equity returns to determine a minimum variance hedge ratio. It is believed that practitioners often do not pursue OHRs due to their instability. Litterman et. al. (2003) argues that correlations are close to zero over long time periods but that changing correlations over time provide rationale for an active currency hedging program. The ex-ante hedge ratio we examine incorporates these findings and dynamically adjusts the hedge ratio as market conditions change.[17]

4.3.1 Minimum variance optimum hedge ratios

In Table 3, for each market, we compare the hedge ratio from an ex-post hedging strategy (PHR) that reflects full period knowledge of currency returns to the hedge ratio for the ex-ante strategy (AHR), as well as three other strategies: unhedged (HR0); partial hedge (HR0.5); and full hedge (HR1) positions. A survey by Russell/Mellon finds that about 13 percent of institutional investors use hedge ratios of 0, 50 or 100 percent.[18] We examine these ratios and refer to them as static, heuristic strategies.

[17] Adler and Simon ("Exchange Rate Surprise,"), argue that the optimal hedge ratios cannot be expected to remain stable over time.
Although the use of our ex-ante ratio would require monthly rebalancing, many market participants use a rolling hedge and rebalance monthly or quarterly due to the better availability and liquidity of short term contracts and changing principal values. For example, a 2016 Deloitte study found that 83% of multinationals hedge from using one to three-month hedges versus 29% using hedges greater than two years. Furthermore, nearly 60% use a rolling hedge.

[18] See Schmittmann (2010). He also refers to the need for a dynamic hedge ratio by saying: "Practitioners tend to be pragmatic in determining hedge ratios. Often they use simple hedge ratios of 0, 50, and 100 percent. … We are sympathetic to the notion of ignoring potential correlations of currencies with equities. In our dataset we find that currency-equity correlations are unstable and fluctuate from plus 40 percent in one decade to minus 40 percent in the next decade for some currency-equity pairs."

Examining DMs, there were three markets in Table 1 where the correlation between the currency and equity was significantly positive: Australia, Canada, and Norway. These three markets have PHRs close to one and examining the last column of Table 3 Panel A, the t-test indicates that the PHR is not significantly different from one. However, for the AHR that is allowed to vary over time, the first quartile (Q1) and third quartile (Q3) statistics indicates that the AHR is not constant at 1.0 for Australia and Norway. On the other hand, for Canada the standard deviation of the AHR is minimal, the interquartile range is zero, and a hedge is in place for all months. Altogether, the results for these three countries confirm intuition; when correlations are significantly positive, the natural hedge provided by currency and equity movements is minimal and a full hedge would usually have been instituted by the PHR and AHR strategies. These countries are also known as commodity currencies since a large proportion of their exports are commodities.[19] As mentioned earlier, we would expect currency and equity correlations to be positive in these markets.

In Table 1, there were six markets with significantly negative correlations; France, Germany, Japan, the Netherlands, Switzerland, and the UK. All six markets have the lowest PHRs of all DMs and typically have PHRs that are significantly different from the three static, heuristic strategies (HR0, HR0.5, and HR1). Furthermore, five of the six markets (excepting the UK) have AHRs lower than all other markets and five of the six markets (excepting the Netherlands) have PHRs significantly different than a full hedge (HR1). Of these markets, Japan has the most variation in the AHR over time with the highest standard deviation and interquartile range. Under a risk minimization objective, the AHR for Japan is significantly different from the full hedge HR1, on average implements a hedge ratio of 56%, and is hedged only 65% of the time.

Examining DMs in Panel A more broadly, the full knowledge, risk minimizing PHR is significantly different than the static unhedged position (HR0) in all DMs, and the PHR is significantly different from an HR0.5 in all but two markets. This however does not imply that with full knowledge an investor would have always been fully hedged, because (as noted previously), the PHR is significantly different from HR1 in five markets. Similarly, there is

[19] According to the United Nations Conference on Trade and Development (2021) State of Commodity Dependence report, commodity exports comprise 78%, 71% and 47.5% of total merchandise exports for Norway, Australia and Canada, respectively. These are the highest percentages for the DMs in our study.

substantial variation for the dynamic AHR. The interquartile range is greater than 0.5 for 6 of 11 markets. Altogether, the heterogeneity in the return characteristics of DMs argues for a market specific hedging strategy.

In EMs, the results are quite different. Recall that in Table 1, all correlations were positive for EMs and almost all were significantly so. In 12 EMs, the PHR hedge ratio is not significantly different from that for the ex-ante (AHR) and static full hedge (HR1) strategies. Furthermore, the first quartile of the AHR equals 1.0 in 10 of 13 EMs. As such, when risk minimization is the objective, it is more frequently the case that a full hedge would have been implemented in EMs. Even so it should be noted that in EMs, in the AHR strategy, a hedge is implemented in less than 100% of months in 6 of 13 markets, which may argue for flexibility in a hedging policy.

Summarizing Table 3, the results indicate that a full hedge is sometimes not implemented when minimizing risk in DMs. For five DMs, the PHR is not equal to a full hedge (HR1) despite the risk minimization objective. This reflects the negative correlation between the currency and equity in these markets. In only Canada, with a significantly positive correlation, is an ex-ante hedge implemented every single month and are the PHR and AHR equal to 1. The results for EMs however differ markedly from DMs and are more homogenous. In these markets where positive correlations dominate, the PHR usually results in a full hedge. Given the difference in return characteristics within DMs and that between DMs and EMs, it may be the case that a dynamic hedging strategy, such as the AHR, could result in better performance than that from static strategies. We therefore next evaluate the performance of alternative strategies in Table 4.

4.3.2 Performance of minimum variance hedge ratios

In Table 4, the mean return and standard deviation of returns for the five approaches is presented. Given that the evidence in Table 3 indicates that the risk minimization hedge ratio varies by market and that a dynamic strategy varies over time, we use the AHR as our reference point when comparing performance of the various hedging strategies. First, comparing the full information PHR to the AHR, the AHR results in mean returns that are greater than or equal to that for the PHR in 7 of 11 DMs and 6 of 13 EMs. The AHR provides risk that is less than that for the PHR in 7 of 11 DMs and 6 of 13 EMs. It is remarkable that an ex-ante strategy does as

well as it does compared to a strategy formed ex post. This highlights the importance of a strategy that is flexible and can adjust to changing market conditions.

Comparing the AHR to the "free lunch" HR1, in all DMs but Belgium, the AHR results in the same or lower risk than HR1. If hedging is costly, the AHR would provide less risk at lower costs. Highlighting the need to incorporate the correlation between the currency and equity, for all six DM countries with negative correlations in Table 1, the AHR provides lower risk than the HR1. Perhaps more surprising, even in the positive correlation EMs, the risk-minimizing hedge ratio is the AHR, not the HR1, for 9 of 13 countries. This refutes the idea that the risk-minimizing "free lunch" hedge ratio is a full hedge.

Furthermore, by using the AHR that incorporates correlations, one can sometimes obtain the same or lower risk, higher or the same returns using less hedging than required by the full hedge HR1. This is true in seven DMs (Canada, France, Germany, Netherlands, Norway, Spain, UK) and three EMs (Brazil, Chile, Mexico). In some cases, the AHR provides what one might call the "free lunch and dinner." In four DMs (France, Norway, Spain, UK), the AHR provides higher returns with less risk than HR1. This is also true in the EMs of Brazil, Chile, and Mexico.

Comparing the AHR to HR0.5, except in the case of the UK and Peru, the AHR provides less risk than HR0.5, albeit often at the expense of lower return. Although the mean AHR in Table 3 for DMs is between 0.53 and 0.67 (i.e., around 0.50) for 8 of 11 markets, the AHR provides greater risk reduction in 10 of 11 DMs than the HR0.5, with the sole exception being the U.K. This highlights the importance of a dynamic strategy that adjusts through time for changing market conditions.

Comparing AHR to HR0, the ex-ante strategy always provides lower risk. This indicates that, although correlations between the currency and equity are always less than one and sometimes negative, an unhedged position would not fulfill a risk minimization objective.

Finally, comparing DMs and EMs, the range and magnitudes of risk and return in EMs is larger than that for DMs. This suggests that investors should adopt market specific hedging strategies that are suited to each investor's risk preferences and each market's currency and equity return characteristics. Our results are consistent with the suggestions of Boudoukh et. al.

(2015) and the findings of Campbell et. al. (2010), in that we find that the attractiveness of currency hedging varies by the country equity invested in.

Summarizing Table 4, the ex-ante strategy often provides lower risk than the ex-post strategy and almost always provides lower risk than unhedged (HR0) or partially hedged (HR0.5) strategies. More remarkable is the performance of the AHR versus that of the "free lunch" full hedging strategy of HR1 when minimizing risk. Relative to HR1, the AHR strategy provides the same or lower risk and the same or better return in half of DMs and about a quarter of EMs. In sum, instead of static heuristic hedging strategies, investors would have benefitted from adopting a dynamic ex-ante hedging strategy that reflects specific, changing market return characteristics.

5. Robustness Tests

In future versions of the paper, we plan to add monthly Sharpe ratios (in addition to mean and standard deviation of USD returns) when discussing performance measurement of the PHR, AHR and heuristic strategies, and will test whether the Sharpe ratios of the AHR strategy significantly differ from each of the heuristic strategies. In addition, we will construct PHRs and AHRs based on Sharpe ratio maximization in addition to the results reported herein based on risk minimization, and compare both the hedge ratios and the performance of the strategies utilizing these approaches.

6. Conclusion

When investing internationally, currency risk is an important component of the investment decision. Previous literature offers little definitive guidance on whether, and/or how, currency risk should be hedged. Some advocate a full currency hedge, arguing that, since the expected return for currencies is zero, removing risk results in a free lunch. However, others, mainly practitioners, argue that hedging often fails to reduce the total risk of a foreign investment. In practice, the degree to which currency risk should be hedged depends partly on the correlation between the currency returns and local currency stock returns: when the correlation is low or negative, hedging will be less effective and may actually increase the volatility of foreign stock returns measured in USD terms. We show that this correlation varies substantially within and between developed and emerging markets, and depends on an

economy's characteristics. In 3 of 11 DMs (all heavy commodity exporters) the correlation between currency returns and local currency stock returns is significantly positive, while in 6 DMs it is significantly negative. In contrast, for emerging markets, the correlation is significantly positive for 12 out of 13 countries. These divergent findings across markets suggest that a "one-size fits all" currency hedging strategy is unlikely to be optimal.

The main contribution of our study is that we use a simple, easily implemented ex-ante risk minimizing hedge ratio, and compare the ex-post performance of the hedge ratios generated by our model to three widely-used, simple heuristic strategies: no currency hedge, half currency hedge, and full currency hedge. For developed markets, we find that the mean ex-ante optimal hedge ratio ranges from 0.53 (Netherlands) to 1.00 (Canada). Compared to no hedging, the ex-ante hedging strategy reduces the standard deviation of USD returns for all eleven countries examined. Compared to a half hedge, the ex-ante strategy reduces risk for 10 of 11 countries, and even compared to a full hedge, it reduces risk for 8 of 11 countries.

In the case of emerging markets, our mean ex-ante hedge ratios range from 0.73 (Greece) to 1.00 (5 countries); thus, our model tends to hedge to a greater extent in these markets relative to DMs. Once again, the ex-ante hedging model compares favorably to the heuristic strategies in terms of risk reduction, reducing the standard deviation of USD returns in all 13 countries compared with the no hedge approach, in 12 countries compared to the half hedge approach, and in 10 countries relative to a full hedge approach. The one caveat is that our ex-ante hedging strategy often leads to very different mean returns (in some countries much higher, and in others much lower) than the heuristic strategies in emerging markets. We do not observe this divergence in developed markets, where all strategies lead to broadly similar mean returns in USD terms.

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Table 1: Risk and Return for Local Currency and Unhedged USD Returns
The table reports US dollar equity returns from investing in foreign equity markets. The summary statistics are reported for the period January 1988 - December 2019 (N=384). We report the mean, standard deviation, and correlation between equity returns in the local currency and currency return for each currency. t-stats and F-stats reported using Newey-West standard errors with six lags to correct for autocorrelation. ***, **, * denote significance at the 1%, 5%, and 10% level.

	Mean	Standard Deviation		Equity Ret. LC & Currency Ret. Correlations		COCR 1) amount 2) % of Currency Risk 3) % of Equity Risk in $		Date Range
Panel A: Developed Countries 1988:1 - 2020:12								
Australia								1988:1 - 2019:12
Equity Return in LC	0.51	4.05		0.320	***	1.91%	**	
Currency Return against USD	0.05	3.27		(6.600)		58.25%		
Unhedged Equity Return in USD	0.60	5.95				32.04%		
T-stat / F-stat	(0.513)	(2.283)	***					
Belgium								1988:1 - 2019:12
Equity Return in LC	0.53	5.41		-0.063		0.54%		
Currency Return against USD	0.02	2.93		(-1.238)		18.56%		
Unhedged Equity Return in USD	0.54	5.96				9.12%		
T-stat / F-stat	(0.078)	(1.088)						
Canada								1988:1 - 2019:12
Equity Return in LC	0.57	4.24		0.179	***	1.05%		
Currency Return against USD	0.03	2.55		(3.565)		41.28%		
Unhedged Equity Return in USD	0.62	5.29				19.87%		
T-stat / F-stat	(0.482)	(1.598)	***					
France								1988:1 - 2019:12
Equity Return in LC	0.67	5.37		-0.181	***	0.39%		
Currency Return against USD	0.03	3.30		(-3.606)		11.92%		
Unhedged Equity Return in USD	0.67	5.76				6.82%		
T-stat / F-stat	(-0.003)	(1.016)						
Germany								1988:1 - 2019:12
Equity Return in LC	0.66	5.78		-0.121	**	0.58%		
Currency Return against USD	0.03	3.45		(-2.385)		16.71%		
Unhedged Equity Return in USD	0.67	6.36				9.07%		
T-stat / F-stat	(0.063)	(1.076)						
Japan								1988:1 - 2019:12
Equity Return in LC	0.17	5.66		-0.177	***	0.34%		
Currency Return against USD	0.08	3.12		(-3.524)		10.81%		
Unhedged Equity Return in USD	0.21	5.99				5.62%		
T-stat / F-stat	(0.283)	(0.9147)						

Netherlands							1988:1 - 2019:12
Equity Return in LC	0.70	5.04		-0.127	**	0.44%	
Currency Return against USD	0.02	2.91		(-2.502)		15.23%	
Unhedged Equity Return in USD	0.70	5.49				8.07%	
T-stat / F-stat	(-0.017)	(0.982)					
Norway							1988:1 - 2019:12
Equity Return in LC	0.74	6.36		0.147	***	1.07%	
Currency Return against USD	-0.04	3.05		(2.911)		35.11%	
Unhedged Equity Return in USD	0.73	7.43				14.42%	
T-stat / F-stat	(-0.089)	(1.318)	***				
Spain							1988:1 - 2019:12
Equity Return in LC	0.58	6.16		-0.002		0.68%	
Currency Return against USD	-0.04	2.99		(-0.032)		22.89%	
Unhedged Equity Return in USD	0.54	6.85				10.00%	
T-stat / F-stat	(-0.239)	(1.085)					
Switzerland							1988:1 - 2019:12
Equity Return in LC	0.71	4.52		-0.230	***	0.38%	
Currency Return against USD	0.12	3.15		(-4.616)		12.16%	
Unhedged Equity Return in USD	0.80	4.90				7.81%	
T-stat / F-stat	(0.590)	(0.915)					
United Kingdom							1988:1 - 2019:12
Equity Return in LC	0.46	4.18		-0.212	***	0.51%	
Currency Return against USD	-0.04	3.17		(-5.255)		16.19%	
Unhedged Equity Return in USD	0.39	4.69				10.92%	
T-stat / F-stat	(-0.448)	(1.520)	***				
United States							1988:1 - 2019:12
Equity Return in LC	0.76	4.07		-		-	
Currency Return against USD	-	-		-		-	
Unhedged Equity Return in USD	-	-				-	
T-stat / F-stat	-	-					

	Mean	Standard Deviation		Equity Ret. LC & Currency Ret. Correlations		1) amount 2) % of Currency Risk 3) % of Equity Risk in $		Date Range
Panel B: Emerging Markets:								
Brazil								1994:11 - 2019:12
Equity Return in LC	1.18	7.66		0.310	***	2.76%	**	
Currency Return against USD	-0.38	5.00		(5.642)		55.25%		
Unhedged Equity Return in USD	0.91	10.43				26.51%		
T-stat / F-stat	(-0.878)	(2.104)	***					
Chile								1997:7 - 2019:12
Equity Return in LC	0.46	5.18		0.338	***	1.76%	*	
Currency Return against USD	-0.17	3.22		(5.872)		54.64%		
Unhedged Equity Return in USD	0.34	6.95				25.36%		
T-stat / F-stat	(-0.558)	(1.899)	***					
Greece								1990:3 - 2019:12
Equity Return in LC	0.10	10.37		0.071		0.47%		
Currency Return against USD	-0.13	2.87		(1.352)		16.52%		
Unhedged Equity Return in USD	-0.02	10.85				4.37%		
T-stat / F-stat	(-0.706)	(1.122)						
Hungary								1995:1 - 2019:12
Equity Return in LC	1.43	8.99		0.241	***	1.40%		
Currency Return against USD	-0.25	3.73		(4.278)		37.46%		
Unhedged Equity Return in USD	1.26	10.39				13.45%		
T-stat / F-stat	(-0.777)	(1.187)	*					
India								1993:1 - 2019:12
Equity Return in LC	1.09	7.46		0.412	***	1.04%		
Currency Return against USD	-0.24	2.01		(8.122)		52.03%		
Unhedged Equity Return in USD	0.91	8.51				12.28%		
T-stat / F-stat	(-1.614)	(1.318)	***					
Indonesia								1991:11 - 2019:12
Equity Return in LC	1.33	9.15		0.106	*	2.25%	**	
Currency Return against USD	-0.40	5.61		(1.957)		40.06%		
Unhedged Equity Return in USD	0.97	11.39				19.73%		
T-stat / F-stat	(-0.878)	(2.156)	***					
South Korea								1992:2 - 2019:12
Equity Return in LC	0.84	8.14		0.346	***	1.90%		
Currency Return against USD	-0.06	3.55		(6.735)		53.49%		
Unhedged Equity Return in USD	0.88	10.04				18.91%		
T-stat / F-stat	(0.226)	(1.533)	***					

Mexico									1991:11 - 2019:12
Equity Return in LC	1.20		6.43		0.324	***	1.72%	*	
Currency Return against USD	-0.47		3.51		(6.272)		49.06%		
Unhedged Equity Return in USD	0.80		8.15				21.10%		
T-stat / F-stat	(-2.049)	**	(1.811)	***					
Peru									1995:4 - 2019:12
Equity Return in LC	1.26		8.25		0.186	***	0.15%		
Currency Return against USD	-0.10		0.73		(3.248)		20.60%		
Unhedged Equity Return in USD	1.17		8.40				1.79%		
T-stat / F-stat	(-1.556)		(1.071)						
Philippines									1992:6 - 2019:12
Equity Return in LC	0.65		7.31		0.250	***	0.88%		
Currency Return against USD	-0.18		2.23		(4.685)		39.41%		
Unhedged Equity Return in USD	0.51		8.19				10.73%		
T-stat / F-stat	(-0.919)		(1.388)	***					
Poland									1993:7 - 2019:12
Equity Return in LC	0.89		9.59		0.226	***	1.25%		
Currency Return against USD	-0.17		3.58		(4.133)		34.94%		
Unhedged Equity Return in USD	0.79		10.84				11.55%		
T-stat / F-stat	(-0.450)		(1.129)						
Thailand									1991:11 - 2019:12
Equity Return in LC	0.55		7.32		0.380	***	0.69%		
Currency Return against USD	-0.03		1.48		(7.538)		46.81%		
Unhedged Equity Return in USD	0.56		8.01				8.62%		
T-stat / F-stat	(0.142)		(1.217)	**					
Turkey									1996:1 - 2019:12
Equity Return in LC	2.65		12.56		0.208	***	1.43%		
Currency Return against USD	-1.46		4.66		(3.597)		30.63%		
Unhedged Equity Return in USD	1.27		13.99				10.20%		
T-stat / F-stat	(-3.696)	***	(0.964)						

Table 1.A
Return from cross-product

Panel A: Developed Countries 1988:1 - 2019:12	
Australia	0.04
Belgium	-0.01
Canada	0.02
France	-0.03
Germany	-0.02
Japan	-0.03
Netherlands	-0.02
Norway	0.03
Spain	0.00
Switzerland	-0.03
United Kingdom	-0.03
Panel B: Emerging Markets	
Brazil	0.11
Chile	0.06
Greece	0.02
Hungary	0.08
India	0.06
Indonesia	0.05
South Korea	0.10
Mexico	0.07
Peru	0.01
Philippines	0.04
Poland	0.08
Thailand	0.05
Turkey	0.04

Table 2: Risk & Return of unhedged and full hedged USD returns

The table reports US dollar equity returns for unhedged and full hedged exposures. The summary statistics are reported for January 1988 - December 2019 (N=384) and Emerging markets. For each currency, we report the mean, standard deviation, skewness, and kurtosis. t-stats and F-stats reported using Newey-West standard errors with six lags to correct for autocorrelation. ***, **, * denote significance at the 1%, 5%, and 10% level.

	N	Mean	Standard Deviation		Skewness	Kurtosis	Jarque-Bera Statistic	
Panel A: Developed Countries 1988:1 - 2019:12								
Australia								
Unhedged Equity Return in USD	384	0.60	5.95		-0.21	4.20	26.02	***
Hedged Equity Return in USD		0.55	3.94		-0.16	2.81	2.18	
Diff		0.05	2.01					
T-stat / F-stat		(0.210)	(2.373)	***				
Belgium								
Unhedged Equity Return in USD	384	0.54	5.96		-0.70	8.27	475.12	***
Hedged Equity Return in USD		0.51	5.45		-0.65	7.40	337.38	***
Diff		0.03	0.51					
T-stat / F-stat		(0.175)	(1.048)					
Canada								
Unhedged Equity Return in USD	384	0.62	5.29		-0.58	5.78	144.46	***
Hedged Equity Return in USD		0.50	4.25		-0.42	5.93	148.63	***
Diff		0.12	1.04					
T-stat / F-stat		(1.097)	(1.550)	***				
France								
Unhedged Equity Return in USD	384	0.67	5.76		-0.30	3.89	18.28	***
Hedged Equity Return in USD		0.63	5.39		-0.25	3.63	10.41	***
Diff		0.04	0.37					
T-stat / F-stat		(0.251)	(0.979)					
Germany								
Unhedged Equity Return in USD	384	0.67	6.36		-0.43	4.53	49.15	***
Hedged Equity Return in USD		0.64	5.80		-0.52	3.97	32.31	***
Diff		0.03	0.56					
T-stat / F-stat		(0.159)	(1.031)					
Japan								
Unhedged Equity Return in USD	384	0.21	5.99		0.21	4.78	53.64	***
Hedged Equity Return in USD		0.33	5.66		-0.24	4.00	19.64	***
Diff		-0.12	0.33					
T-stat / F-stat		(-0.702)	(0.912)					

Netherlands								
Unhedged Equity Return in USD	384	0.70	5.49		-0.68	5.17	104.48	***
Hedged Equity Return in USD		0.72	5.06		-0.75	4.58	76.04	***
Diff		-0.02	0.43					
T-stat / F-stat		(-0.136)	(0.941)					
Norway								
Unhedged Equity Return in USD	384	0.73	7.43		-0.47	5.07	82.99	***
Hedged Equity Return in USD		0.62	6.37		-0.75	5.14	109.14	***
Diff		0.11	1.06					
T-stat / F-stat		(0.672)	(1.265)	**				
Spain								
Unhedged Equity Return in USD	384	0.54	6.85		-0.01	4.47	34.78	***
Hedged Equity Return in USD		0.39	6.26		-0.06	4.51	36.65	***
Diff		0.15	0.59					
T-stat / F-stat		(0.896)	(1.042)					
Switzerland								
Unhedged Equity Return in USD	384	0.80	4.90		-0.19	4.75	51.49	***
Hedged Equity Return in USD		0.82	4.56		-0.39	4.91	68.45	***
Diff		-0.02	0.34					
T-stat / F-stat		(-0.116)	(0.873)					
United Kingdom								
Unhedged Equity Return in USD	384	0.39	4.69		-0.11	3.91	13.97	***
Hedged Equity Return in USD		0.33	4.18		-0.27	3.83	15.84	***
Diff		0.06	0.51					
T-stat / F-stat		(0.431)	(1.510)	***				
United States								
Unhedged Equity Return in USD	384	0.76	4.07		-0.59	4.23	46.90	***
Hedged Equity Return in USD								
Diff								
T-stat / F-stat								

Panel B: Emerging Markets

Brazil									
Unhedged Equity Return in USD	302	0.91		10.43		0.01	3.80	8.03	**
Hedged Equity Return in USD		0.06		7.66		-0.24	4.77	42.33	***
Diff		0.85		2.77					
T-stat / F-stat		(2.771)	***	(0.475)	***				
Chile									
Unhedged Equity Return in USD	270	0.34		6.95		-0.17	4.24	18.67	***
Hedged Equity Return in USD		0.20		5.22		-0.22	5.35	64.00	***
Diff		0.14		1.73					
T-stat / F-stat		(0.781)		(0.527)	***				
Greece									
Unhedged Equity Return in USD	358	-0.02		10.85		0.38	5.19	79.69	***
Hedged Equity Return in USD		-0.08		10.38		0.69	5.81	146.16	***
Diff		0.06		0.47					
T-stat / F-stat		(0.393)		(0.891)					
Hungary									
Unhedged Equity Return in USD	300	1.26		10.39		0.12	5.86	103.26	***
Hedged Equity Return in USD		1.61		8.96		0.66	8.13	350.91	
Diff		-0.35		1.43					***
T-stat / F-stat		(-1.718)	*	(0.843)					
India									
Unhedged Equity Return in USD	324	0.91		8.51		0.29	4.14	22.25	***
Hedged Equity Return in USD		1.34		7.46		0.16	3.93	13.15	***
Diff		-0.43		1.05					
T-stat / F-stat		(-3.506)	***	(0.759)	***				
Indonesia									
Unhedged Equity Return in USD	338	0.97		11.39		0.54	7.98	364.81	***
Hedged Equity Return in USD		2.78		10.27		0.58	6.19	162.82	***
Diff		-1.81		1.12					
T-stat / F-stat		(-2.829)	***	(0.464)	***				
South Korea									
Unhedged Equity Return in USD	335	0.88		10.04		0.94	8.47	467.16	***
Hedged Equity Return in USD		0.68		8.16		0.92	7.68	353.11	***
Diff		0.20		1.88					
T-stat / F-stat		(1.092)		(0.652)	***				

Mexico										
Unhedged Equity Return in USD	338	0.80		8.15		-0.57	4.83	65.30	***
Hedged Equity Return in USD		1.42		6.44		-0.08	3.77	8.80	**
Diff		-0.62		1.71					
T-stat / F-stat		(-3.162)	***	(0.552)	***				
Peru									
Unhedged Equity Return in USD	297	1.17		8.40		0.19	5.98	111.77	***
Hedged Equity Return in USD		0.89		8.27		0.18	5.73	94.14	***
Diff		0.28		0.13					
T-stat / F-stat		(6.239)	***	(0.933)					
Philippines									
Unhedged Equity Return in USD	331	0.51		8.19		0.74	7.81	349.17	***
Hedged Equity Return in USD		0.81		7.27		0.68	6.92	237.92	***
Diff		-0.30		0.92					
T-stat / F-stat		(-1.663)	*	(0.721)	***				
Poland									
Unhedged Equity Return in USD	318	0.79		10.84		0.15	4.50	31.01	***
Hedged Equity Return in USD		0.60		9.53		0.44	6.26	151.10	***
Diff		0.19		1.31					
T-stat / F-stat		(0.931)		(0.886)					
Thailand									
Unhedged Equity Return in USD	338	0.56		8.01		0.65	5.29	97.54	***
Hedged Equity Return in USD		0.46		7.30		0.75	6.17	173.32	***
Diff		0.10		0.71					
T-stat / F-stat		(1.081)		(0.822)	*				
Turkey									
Unhedged Equity Return in USD	288	1.27		13.99		0.56	5.73	104.43	***
Hedged Equity Return in USD		2.76		15.46		-0.44	9.55	524.00	***
Diff		-1.49		-1.47					
T-stat / F-stat		(-1.249)		(1.037)					

Table 3

The table reports the minimum variance optimal hedge ratios. The table presents the ex-post optimal hedge ratio and the Ex-ante optimal hedge ratio with sample statistics. The ex-ante optimal hedge ratio is calculated using 36 rolling months. A hedged month occurs when the ex-ante OHR is greater than zero for that month. Panel A presents results for January 1988 through December 2019 (N=384), and Panel B presents results for emerging markets. t-Stats are reported using Newey-West standard errors with 6 lags to correct for autocorrelation. ***, **, * denote significance at the 1%, 5%, and 10% level.

Panel A: Developed Countries 1988:1 - 2019:12

		Ex-ante Optimal Hedge Ratio						t-Test Results Ex post OHR								
	Constr. Ex-post OHR	mean	Std. Dev	Q1	Q3	N	Hedged Months	Ex-ante		0		0.5		1		
Australia	0.96	0.89	0.13	0.80	1.00	384	384	1.40		18.50	***	8.90	***	-0.69		
								(0.164)		(0.000)		(0.000)		(0.489)		
Belgium	0.85	0.64	0.33	0.42	1.00	384	365	1.39		5.67	***	2.35	**	-0.96		
								(0.164)		(0.000)		(0.019)		(0.336)		
Canada	1.00	1.00	0.01	1.00	1.00	384	384	0.00		11.67	***	5.83	***	0.00		
								(1.000)		(0.000)		(0.000)		(1.000)		
France	0.70	0.61	0.31	0.44	0.89	384	349	0.79		6.35	***	1.79	*	-2.76	***	
								(0.429)		(0.000)		(0.074)		(0.006)		
Germany	0.79	0.61	0.31	0.38	1.00	384	378	1.72	*	7.84	***	2.85	***	-2.13	**	
								(0.087)		(0.000)		(0.005)		(0.034)		
Japan	0.68	0.56	0.45	0.00	1.00	384	251	0.87		5.20	***	1.36		-2.47	**	
								(0.384)		(0.000)		(0.174)		(0.014)		
Netherlands	0.78	0.53	0.33	0.28	0.83	384	354	1.78	*	5.50	***	1.96	*	-1.58		
								(0.076)		(0.000)		(0.051)		(0.115)		
Norway	1.00	0.75	0.29	0.48	1.00	384	384	1.77	*	6.96	***	3.48	***	0.00		
								(0.077)		(0.000)		(0.001)		(1.000)		
Spain	0.91	0.66	0.32	0.46	1.00	384	350	1.42		5.13	***	2.31	**	-0.51		
								(0.155)		(0.000)		(0.022)		(0.608)		

Switzerland	0.64	0.54	0.29	0.36	0.69	384	361	1.09	6.57	***	1.47		-3.63	***
								(0.278)	(0.000)		(0.142)		(0.000)	
United	0.73	0.67	0.27	0.49	0.88	384	378	0.86	9.59	***	3.06	***	-3.48	***
Kingdom								(0.390)	(0.000)		(0.002)		(0.001)	

Panel B: Emerging Markets

		Ex-ante Optimal Hedge Ratio						t-Test Results Ex post OHR						
	Constr. Ex-post OHR	mean	Std. Dev	Q1	Q3	N	Hedged Months	Ex-ante	0		0.5		1	
Brazil	1.00	0.99	0.06	1.00	1.00	266	266	0.08	5.65	***	2.82	***	0.00	
								(0.938)	(0.000)		(0.005)		(1.000)	
Chile	1.00	1.00	0.01	1.00	1.00	234	234	0.00	11.35	***	5.68	***	0.00	
								(1.000)	(0.000)		(0.000)		(1.000)	
Greece	1.00	0.73	0.36	0.46	1.00	322	284	1.10	4.00	***	2.00	**	0.00	
								(0.272)	(0.000)		(0.046)		(1.000)	
Hungary	1.00	0.88	0.31	1.00	1.00	264	239	0.83	6.66	***	3.33	***	0.00	
								(0.407)	(0.000)		(0.001)		(1.000)	
India	1.00	1.00	0.04	1.00	1.00	288	288	0.01	3.68	***	1.84	*	0.00	
								(0.991)	(0.000)		(0.067)		(1.000)	
Indonesia	0.71	0.77	0.40	0.75	1.00	302	251	-0.33	3.89	***	1.14		-1.60	
								(0.740)	(0.000)		(0.254)		(0.110)	
South Korea	1.00	1.00	0.00	1.00	1.00	299	299	0.00	5.57	***	2.78	***	0.00	
								(1.000)	(0.000)		(0.006)		(1.000)	
Mexico	1.00	1.00	0.03	1.00	1.00	302	302	0.03	8.28	***	4.14	***	0.00	
								(0.973)	(0.000)		(0.000)		(1.000)	
Peru	1.00	0.87	0.32	1.00	1.00	261	236	0.19	1.46		0.73		0.00	
								(0.853)	(0.147)		(0.467)		(1.000)	
Philippines	1.00	0.95	0.15	1.00	1.00	295	295	0.16	3.22	***	1.61		0.00	
								(0.870)	(0.001)		(0.109)		(1.000)	
Poland	1.00	0.91	0.26	1.00	1.00	282	262	0.57	6.49	***	3.24	***	0.00	
								(0.569)	(0.000)		(0.001)		(1.000)	

Thailand	1.00	1.00	0.00	1.00	1.00	302	302	0.00		4.15	***	2.07	**	0.00	
								(1.000)		(0.000)		(0.039)		(1.000)	
Turkey	0.28	0.74	0.43	0.14	1.00	252	216	-2.67	***	1.65	*	-1.28		-4.21	***
								(0.008)		(0.100)		(0.201)		(0.000)	

Table 4
Performance of risk minimizing ex-post versus ex-ante and heuristic OHRs. The ex-ante optimal hedge ratio is calculated using 36 rolling months. Panel A presents results for January 1988 through December 2019 (N=384), and Panel B presents results for the emerging markets.

Panel A: Developed Countries 1988:1 - 2019:12

	Constr. Ex-post OHR		Constr. Ex-ante OHR		OHR=0 return		OHR=0.5 return		OHR=1 return	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Australia	0.55	3.94	0.51	3.93	0.56	5.96	0.55	4.49	0.55	3.94
Belgium	0.52	5.43	0.51	5.49	0.55	5.99	0.53	5.53	0.51	5.45
Canada	0.50	4.25	0.50	4.25	0.60	5.33	0.55	4.65	0.50	4.25
France	0.65	5.29	0.65	5.19	0.70	5.77	0.66	5.33	0.63	5.39
Germany	0.65	5.75	0.64	5.79	0.69	6.36	0.67	5.84	0.64	5.80
Japan	0.30	5.56	0.31	5.30	0.24	5.95	0.29	5.59	0.33	5.66
Netherlands	0.72	5.01	0.72	4.95	0.71	5.49	0.72	5.07	0.72	5.06
Norway	0.62	6.37	0.67	6.37	0.70	7.45	0.66	6.76	0.62	6.37
Spain	0.41	6.25	0.45	6.12	0.54	6.85	0.47	6.37	0.39	6.26
Switzerland	0.82	4.42	0.76	4.43	0.83	4.88	0.82	4.45	0.82	4.56
United Kingdom	0.35	4.08	0.38	4.15	0.42	4.68	0.37	4.14	0.33	4.18

Panel B: Emerging Markets

	Constr. Ex-post OHR		Constr. Ex-ante OHR		OHR=0 return		OHR=0.5 return		OHR=1 return	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Brazil	0.06	7.66	0.14	7.45	0.79	10.37	0.43	8.76	0.06	7.66
Chile	0.20	5.22	0.33	4.70	0.29	6.97	0.24	5.95	0.20	5.22
Greece	-0.08	10.38	-0.27	9.61	-0.04	10.96	-0.06	10.57	-0.08	10.38
Hungary	1.61	8.96	0.99	8.22	0.85	10.24	1.39	9.60	1.61	8.96
India	1.34	7.46	1.48	7.47	0.85	8.49	1.09	7.93	1.34	7.46
Indonesia	2.24	10.12	1.78	10.06	0.93	11.23	1.85	10.24	2.78	10.27
South Korea	0.68	8.16	0.72	8.19	0.78	9.95	0.73	8.92	0.68	8.16
Mexico	1.42	6.44	1.44	6.25	0.73	8.27	1.07	7.19	1.42	6.44
Peru	0.89	8.27	0.87	8.40	1.16	8.42	1.03	8.34	0.89	8.27
Philippines	0.81	7.27	0.70	6.87	0.47	8.16	0.64	7.64	0.81	7.27
Poland	0.60	9.53	0.37	7.71	0.71	10.97	0.66	10.12	0.60	9.53
Thailand	0.46	7.30	0.34	6.79	0.52	8.00	0.49	7.62	0.46	7.30
Turkey	1.63	14.01	2.18	12.47	1.19	14.28	1.97	14.13	2.76	15.46