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Conditional Currency Hedging for International Equity Portfolio

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Conditional Currency Hedging for International Equity Portfolio

Abstract

The given study focuses on international equity portfolios based in seven developed economies and examines whether conditional approach to unitary, universal, and minimum variance currency hedging outperforms the commonly used unconditional approach in terms of minimizing risk without compromising returns. Capturing the period from 1980 until 2016, the out-of-sample Sharpe ratio results reveal that for six out of seven observed countries the conditional approach outperforms the unconditional for all examined hedging strategies. The obtained results lack statistical significance, which can be attributed to inconsistent performance of conditional hedging during the global financial crisis, as well as the problems with the forecasting indicator and estimation errors in hedging weights. Yet, the study reveals a big potential of conditional currency hedging for equity investors and points toward the factors which can further improve the given strategy.

Introduction

Holding international assets is a common practice employed with a purpose of reducing portfolio risk. Yet, international diversification exposes the portfolio to the risk of exchange rate fluctuations, thus, prompting an investor to consider whether to hedge his currency exposure, and if so – which strategy to choose.

Unitary, universal, and minimum variance are the most common strategies of currency risk hedging. Numerous research has proven their effectiveness at reducing portfolio volatility. However, recent empirical studies (De Roon, Eiling, Gerard & Hillion, 2014) provide evidence showing that currency hedging has a cost: while reducing the risk, it also cuts portfolio returns, which come from profitable currency exposure.

In the given study we employ a conditional, or selective approach to currency risk hedging with an aim to investigate whether conditional hedging can address the downside of simple unconditional strategies and offer a better hedging alternative to global equity investors. The novelty of our conditional strategy is in timing the hedge only to the periods of expected foreign currency depreciation. By

"turning the hedge off" when foreign currency is forecasted to appreciate, we expect to capture currency returns, which are naturally embedded in investment positions, and thus minimize the negative effect of hedging on portfolio returns. Similarly to Campbell, Serfaty-De Medeiros & Viceira (2010), we use seven major currencies: Australian dollar, Canadian dollar, euro, Japanese yen, Swiss franc, British pound, and the US dollar, and simulate the strategy where the decision to hedge depends on one-month predictions of interest rate differential. Our main objective is to investigate the out-of-sample performance of the conditional currency hedging and compare its risk-adjusted returns with those achieved by the unconditional approach.

This paper is structured as follows. Section I reviews the related literature and theory of currency hedging. Methodology is laid out in Section II. Section III follows by describing the data and presenting the preliminary statistical analysis of stock and currency returns. Section IV reports the main findings: the out-of-sample performance of conditional versus unconditional approach to the unitary, universal, and minimum variance hedging strategies, and compares their Sharpe ratios. Section V analyzes the results and discusses the possible problems, and Section VI concludes.

Section I. Theory and Related Literature

1.1 Currency Risk Hedging

International diversification is a widespread practice among investors and asset managers, regarded as a means to reduce overall portfolio risk. However, cross-border diversification exposes investments to another source of risk – fluctuations of currency exchange rates – which is due to the fact that the return of internationally diversified portfolio is comprised of a return on foreign assets and a return on foreign currency.

Consider, for example, a US investor who holds German stock portfolio. The dollar return on his investment can be expressed the following way:

$$R_{t+1}^{\$} = \frac{P_{t+1}^{€} S_{t+1}}{P_t^{€} S_t} - 1 = \left(1 + R_{t+1}^{€}\right)(1 + \Delta S_{t+1}) - 1;$$

where S_t denotes the spot dollar price for one Euro at time t, $P_t^{€}$ is the stock price in Euros at time t, and $\Delta S_{t+1} = \frac{S_{t+1}}{S_t} - 1 -$ the return on USD-EUR exchange rate (De Roon et.al., 2014, p. 5).

If the investor keeps the portfolio unhedged, he will receive the foreign currency value of the investment times the spot exchange rate prevailing at the end of the period. Alternatively, he may choose to hedge his currency exposure by locking in the exchange rate with a forward contract. (VanderLinden, Jiang & Hu, 2002). Suppose the investor decides to hedge his German stock portfolio and sells Euro forward by the amount of $-\omega_t^{hedge}/S_t$. Then, the return on the hedged investment is

$$R_{t+1}^{hedged} = R_{t+1}^{\$} + \omega_t^{hedge} r_{t+1}^{c} ;$$

where $r_{t+1}^{c} = \frac{F_{t,t+1} - S_{t+1}}{S_t}$. $F_{t,t+1}$ in the given equation denotes "the predetermined forward exchange rate in US dollars for selling one Euro with delivery at time $t+1$" (De Roon et.al., 2014, p. 5).

But what is the optimal hedging position ω_t^{hedge}? This issue is of high practical importance for every global investor. It is also a topic of an ongoing academic debate and controversy.

1.2 Zero Expected Currency Returns

Assuming that currencies have zero expected returns, currency risk hedging offers a way to reduce the portfolio variance while leaving the portfolio expected returns unaffected. With this assumption, optimal hedge solely minimizes the portfolio volatility. The research of Solnik (1974) shows that in case of zero correlation between exchange rates changes and equity returns, the optimal currency hedge is unitary (full), with hedging ratio $\omega_t^{hedge} = -1$. Perold and Shulman (1988) also support the unitary hedging strategy, arguing that currency hedging is a "free lunch": an effective way to substantially reduce the volatility of cross-border portfolio without affecting its returns. The study acknowledges, however, that this strategy does not necessarily minimize the risk. If the correlation is non-zero, full hedge is sub-optimal. The optimal currency risk hedge, then, is a minimum variance hedge (De Roon et. al., 2014):

$$\omega^{hedge} = -\frac{Cov(R^{\$}, r^{c})}{Var(r^{c})}.$$

"If currency and unhedged equity returns are positively correlated, the foreign currency depreciates when the foreign investment has negative returns. Therefore, the currency receives a negative weight in the hedging portfolio." (De Roon et. al., 2014, p. 6). Simulating the given strategy on seven most developed markets, Campbell et. al. (2010) find that minimum variance hedging achieves significant improvements of portfolio volatility as compared to the unitary hedge. They show that the optimal strategy for a global investor is to take short positions in currencies that are positively correlated with equity returns (such as the Australian dollar, Canadian dollar, Japanese yen and British pound) and take long positions in currencies that have negative correlation with equity returns (such as the US dollar, euro and the Swiss franc) (Campbell et. al., 2010).

Froot (1993), on the other hand, argues that long-term investors do not need to hedge currency risk as they are naturally hedged by mean-reverting real exchange rates. However, a more extensive study by Schmittmann (2010) finds that the need for hedging generally does not decrease with longer investment horizons.

1.3 Nonzero Expected Currency Returns

So far, the optimal currency hedging discussion rested on the assumption that currencies have zero expected returns. Therefore, the literature has been mostly considering the impact of hedging on portfolio volatility, leaving portfolio returns out of focus. However, the studies of De Santis and Gerard (1998) and Lustig and Verdelhan (2007), among others, provide empirical evidence of a currency risk premium, which prompts to reconsider the validity of zero expected returns assumption.

"If currencies have nonzero expected returns, they may be considered a separate asset class rather than purely hedging instruments" (De Roon et. al., 2014, p. 7). Hence, for speculative reasons an investor may choose to leave the currency exposure embedded in his international portfolio and even actively add currency positions. The "Siegel's paradox", which arises from Jensen's inequality (Siegel, 1972), shows that investors in different countries may simultaneously perceive positive expected excess returns on foreign currencies over their domestic ones, and by adding some currency risk can all increase their expected returns. Based on this paradox and additional assumptions, Black (1989, 1990) derives a universal hedging formula, suggesting that, regardless of their

nationality, investors should use identical (universal) hedge ratios and should never hedge 100 percent of their foreign equity.

"A more important source of speculative currency demand arises from expected excess returns on particular currencies" (Campbell et al., 2010, p. 91). The studies on forward premium anomaly (Fama (1984), Engel (1996)) point out that currencies with high short-term interest rates tend to deliver high returns. This phenomenon is exploited by currency carry trade – a well-known speculative strategy that takes long (short) positions in currencies with positive (negative) expected returns (De Roon et. al., 2014).

Considering both hedging and speculative positions in currency forwards, Glen and Jorion (1993) find that "the improvement in Sharpe ratios is mostly due to the hedging component rather than the speculative component. However, the results lose significance when using only equity portfolios as base assets or when using overlay strategies" (De Roon et. al., 2014, p. 7). More vivid evidence on historical profitability of speculative currency strategies is documented in carry trade literature (Burnside, Eichenbaum, Kleshchelski & Rebelo (2006), Brunnermeier, Nagel & Pedersen (2009)).

Returning to risk hedging, the minimum variance strategy is optimal only in light of zero currency expected returns. The research of De Roon et. al. (2014) shows that if this assumption is violated in data, hedging comes at a serious cost. Their out-of-sample study is the first one that goes beyond volatility analysis and takes into consideration the effect of currency risk hedging on portfolio returns and other moments. The findings show that while reducing portfolio volatility, hedging also significantly lowers portfolio returns (monthly equity returns decrease by 45%), and does not improve the Sharpe ratio. Moreover, currency hedging worsens portfolio skewness and increases kurtosis. Consequently, if an investor cares not only about variance, employing a hedge might be less "optimal" for his portfolio than not hedging at all.

Given these findings, our paper proposes and tests currency risk management strategies which could possibly reduce portfolio volatility for a global equity investor without lowering his returns. As De Roon et. al. (2014) point out, "hedging lowers overall portfolio returns because the hedging portfolio takes short positions in currencies when they have positive expected returns" (p.2). An investor could possibly address this issue by implementing a conditional

hedge: by taking short currency positions for the periods of negative expected currency returns and leaving the portfolio unhedged when expected currency returns are positive, thus retaining the benefit from natural currency exposure embedded in his cross-border assets. This is the basic idea behind the strategy we test in the given paper.

1.4 Conditional Hedging

The success of the proposed strategy depends to a large extent on how correctly we time currency hedging. Therefore, an appropriate variable that is able to predict future exchange rate movements should be employed.

One of the most popular predicting variables of future exchange rates is interest rate differential / forward discount ($\frac{F_{t,t+1}-S_t}{S_t} \approx i_d - i_f$). Under uncovered interest rate parity (UIP), the forward discount (premium) should be "an unbiased estimate of the subsequent exchange rate change" (Froot, 1990, p. 182), forecasting foreign currency depreciation (appreciation). However, multiple studies on forward discount did not confirm the theory and found an opposite relationship: currencies with relatively higher interest rates tend to appreciate instead (Hansen & Hodrick, 1980; Fama, 1984). The study by Clarida, Davis & Pedersen (2009), though, points out that in high volatility environments interest rates and currency exchange rates revert to a positive relationship.

The violation of UIP and the presence of forward discount bias has been the main driver behind carry trade gains. Glen & Jorion (1993) show that conditional speculative strategy outperforms unconditional full and universal strategies and yields "substantially higher returns without additional risk" (Glen & Jorion, 1993, p. 1885).

The predicting power of forward discount and interest rate differential can also be used for risk hedging needs. VanderLinden et al. (2002) test several conditional hedging strategies. The study employs the "Forward Hedge Rule" based on nominal interest rates, the "Real-Interest-Rate Hedge Rule" (Hazuka & Huberts, 1994), and "The Real Forward Hedge Rule" (RFHR), which is a combination of the two strategies. The study finds that the combined strategy outperforms others, and, more importantly, that the conditional currency risk hedging strategies provide higher statistically significant Sharpe ratios than the unconditional ones.

Our study will test the simple version of conditional currency risk hedging, which will enter into a short forward position when the expected currency return is negative and will refrain from hedging in light of expected positive currency returns. Due to the need to time hedging to specific periods, our strategy will be conditioned on the predicting power of nominal and real interest rate differential.

Section II. Methodology

In this paper we use currencies of seven developed economies: Australia, Canada, Germany, Japan, Switzerland, the United Kingdom, and the United States, and assume that a global investor in each country equally invests in the seven stock markets. Having set up the unhedged equally-weighted equity portfolio as a base portfolio, we add to it currency positions in an overlay fashion. Rebalancing is done on a monthly basis to achieve more precise comparison of different hedging strategies. All transaction costs are disregarded.

For the unitary hedge we use the hedging ratio $\omega_t^{hedge} = -1$, and for the universal strategy we employ hedging weight proposed by Black (1989):

$$\omega^{hedge} = -\frac{\mu_m - \sigma_m^2}{\mu_m - \frac{1}{2}\sigma_e^2}.$$

The equation relies on thee inputs: μ_m denotes the average across investors of the excess return on the world market portfolio, σ_m is the average volatility of the world market portfolio, and σ_e is the average exchange rate volatility across all pairs of countries (Black, 1989, pp. 162-163). The universal weight is calculated every month, based on the preceding 60 months of data.

For the minimum variance hedging strategy the weight ω^{hedge} in month *t* is estimated by regressing unhedged portfolio returns on six currency forward returns, using the past 60 months of returns (De Roon et. al., 2014):

$$R_{p,\tau}^x = \alpha + \beta_1 r_{1,\tau}^c + \beta_2 r_{2,\tau}^c + \ \ldots\ + \beta_6 r_{6,\tau}^c + \varepsilon_\tau,$$

$$\text{for } \tau = t-1, \ldots, t-60\ ;$$

where $R_{p,\tau}^x$ denotes the excess returns on the unhedged international stock portfolio, and $r_{N,\tau}^c$ is the returns on N currency forwards. The result of the regression is the hedging weight for every foreign currency, $\omega^{hedge} = -\hat{\beta}$.

The out-of-sample hedged returns r_t^h for a country are calculated as:

$$r_t^h = r_t^x + \omega^{hedge} * r_t^c,$$

where r_t^x denotes unhedged country portfolio returns (De Roon et. al., 2014, p. 9).

Our conditional hedging strategies (conditional unitary, universal, and minimum variance) employ the interest rate differential as a predicting variable of future exchange rate changes. Denoting domestic riskless interest rate as $i_{d,t}$, and foreign riskless interest rate as $i_{f,t}$, we observe $i_{f,t} - i_{d,t}$ for every month. When $i_{f,t} - i_{d,t} > 0$, we leave the portfolio unhedged in light of the expected foreign currency appreciation, and when $i_{f,t} - i_{d,t} \leq 0$, the currency exposure is hedged with the weight ω^{hedge}, which depends upon a type of a hedging strategy.

For the conditional minimum variance strategy we use a slightly adjusted approach. If $i_{f,t} - i_{d,t} \leq 0$, we assign $I_{hedge,N,t} = 1$, denoting that at time *t* the given currency N should be hedged, and if $i_{f,t} - i_{d,t} > 0$, then $I_{hedge,N,t} = 0$. The hedging weights for the conditional minimum variance strategy are then found from the following regression:

$$R_{p,\tau}^x = \alpha + \beta_1 r_{1,\tau}^c * I_{hedge,1,t} + \beta_2 r_{2,\tau}^c * I_{hedge,2,t} + \cdots + \beta_6 r_{6,\tau}^c * I_{hedge,6,t} + \varepsilon_\tau,$$

$$\text{for } \tau = t-1, \ldots, t-60.$$

This approach allows to improve the accuracy of hedging weights by eliminating from the regression the betas of those currencies which should not be hedged.

The statistical significance of the differences in Sharpe ratios obtained through conditional versus unconditional strategies is tested using the approach derived by Opdyke (2007). This approach permits "time-varying conditional volatilities, serial correlation, and other non-iid returns behavior" (p. 308). The results of Sharpe ratio differences presented in the Section IV are obtained from Opdyke's spreadsheet, which is accessible at the author's website at www.DataMineIt.com.

Section III. Data and Summary Statistics

The out-of-sample analysis of the given study is based on monthly observations. Stock returns are retrieved from MSCI Database, data on exchange rates – from Federal Reserve website, inflation rates were extracted from OECD, and short-term interest rates obtained from Datastream. The data sample begins in

July 1975 and ends in December 2016. Monthly data for Australia begins in 1976, and for Japan it starts in 1978. These countries are incorporated in the sample as soon as their data becomes available. Due to the fact that the universal and the minimum variance hedging strategy is constructed based on preceding 60 months of data, the performance of all strategies is reported and compared beginning July 1980.

Table I provides summary statistics for average interest rates and excess stock returns for the seven observed countries. The data reported in all tables is monthly and annualized, capturing the full sample (1980:07- 2016:12), unless otherwise specified. Summary statistics for three sub-sample periods can be found in the Appendix A.

Table I. Interest Rates and Stock Returns.

	USA	*Germany*	*Canada*	*Switzerland*	*UK*	*Japan*	*Australia*
Nominal interest rates							
Average	5.20%	4.90%	6.77%	3.37%	7.92%	2.90%	9.11%
St. deviation	4.35%	2.69%	4.36%	2.59%	4.13%	2.93%	4.71%
Real interest rates							
Average	2.01%	2.82%	3.61%	1.67%	4.40%	1.98%	4.96%
St. deviation	2.92%	1.80%	2.75%	1.72%	3.06%	1.90%	2.92%
Excess stock returns in local currency							
Average	7.26%	6.72%	3.21%	7.33%	4.46%	3.82%	3.19%
St. deviation	14.99%	20.64%	15.55%	15.81%	15.50%	19.12%	16.84%

Currency (forward) excess returns are reported in a Table II. The rows of the table correspond to investors based in each of the seven countries. The excess return on a currency is calculated as: $\frac{S_{t+1} * (1+i_{f,t})}{S_t * (1+i_{d,t})} - 1$, where S_t denotes current spot rate, while $i_{f,t}$ and $i_{d,t}$ – current foreign and domestic short-term interest rates.

We find that excess returns on currencies have much lower means compared to stock returns. Over the given sample period investors based in the USA, Germany, Switzerland, and Japan had on average positive excess returns on all six foreign currencies, while an Australia-based investor had negative currency returns. This data implies that the Australian investor could have increased his portfolio returns by employing currency hedging, while investors with positive currency excess returns would have most likely reduced their overall portfolio returns by unconditional hedging strategies.

Table II. Currency Excess Returns For Investors Based In Each Observed Country.

	USD	*EUR*	*CAD*	*CHF*	*GBP*	*JPY*	*AUD*
USA		0.23%	1.32%	0.26%	1.37%	0.30%	3.11%
st.dev.		10.92%	7.12%	11.71%	10.32%	11.53%	11.38%
Germany	0.97%		2.04%	0.11%	1.58%	0.72%	3.58%
st.dev.	10.97%		10.89%	5.74%	8.65%	11.94%	12.16%
Canada	-0.80%	-0.83%		-0.73%	0.32%	-0.54%	1.80%
st.dev.	7.20%	10.87%		12.32%	10.53%	13.31%	9.31%
Switzerland	1.11%	0.21%	2.25%		1.75%	0.73%	3.79%
st.dev.	11.67%	5.55%	12.16%		9.74%	11.52%	13.28%
UK	-0.29%	-0.81%	0.79%	-0.76%		-0.36%	2.37%
st.dev.	10.35%	8.77%	10.56%	10.01%		12.95%	12.36%
Japan	1.01%	0.67%	2.28%	0.58%	2.00%		3.93%
st.dev.	11.39%	11.64%	12.96%	11.35%	12.53%		14.69%
Australia	-1.73%	-2.00%	-0.91%	-1.90%	-0.81%	-1.62%	
st.dev.	11.63%	12.37%	9.41%	13.60%	12.43%	15.28%	

Table III presents cross-country return correlations of stock excess returns and currency excess returns. The reported currencies correlation is an average across all base countries.

Table III. Cross-Country Excess Return Correlations.

Panel A: Stocks

	USA	*Germany*	*Canada*	*Switzerland*	*UK*	*Japan*	*Australia*
USA	1.00						
Germany	0.64	1.00					
Canada	0.76	0.53	1.00				
Switzerland	0.67	0.71	0.57	1.00			
UK	0.73	0.63	0.63	0.68	1.00		
Japan	0.45	0.43	0.42	0.44	0.44	1.00	
Australia	0.57	0.48	0.60	0.52	0.59	0.40	1.00

Panel B: Currencies

	USA	*Germany*	*Canada*	*Switzerland*	*UK*	*Japan*	*Australia*
USA	1.00						
Germany	0.44	1.00					
Canada	0.81	0.46	1.00				
Switzerland	0.35	0.87	0.28	1.00			
UK	0.54	0.66	0.50	0.53	1.00		
Japan	0.54	0.46	0.34	0.51	0.40	1.00	
Australia	0.48	0.42	0.70	0.27	0.39	0.26	1.00

The correlations between stock returns, which are reported in Panel A, range from 40% to 76%. The lowest correlations are exhibited between Japanese stock market and other markets, which can be attributed to poor equity market performance in Japan during 1990s as compared to other countries (see the Appendix A for country average excess stock returns in 1990:01-2003:12). On the

other hand, the highest correlation coefficients are found between Canada and the USA, the UK and the USA, and between Switzerland and Germany, which can be explained by financial links and the interconnection of the given economies. Overall, the reported correlations suggest the presence of substantial benefit of international diversification for an equity investor during the given sample period.

Panel B shows that all currency excess returns are positively cross-correlated. Particularly remarkable is high correlation of the Canadian dollar with the US dollar (81%) and with the Australian dollar (70%), which Campbell explains by "the dual role of the Canadian economy as a resource-dependent economy that is simultaneously highly integrated with the United States" (2010, p. 95). Extremely high correlation is also observed between the Euro and the Swiss Franc (87%), which is attributed to the economic interconnection within the European market.

Section IV. Conditional Currency Hedging Performance

For every country investor we begin by constructing an unhedged equally-weighted global stock portfolio. Then, three currency risk hedging strategies are employed – unitary, universal, and minimum variance. Within each of these three strategies we test portfolio performance under the unconditional approach, which employs a hedge at all times, and the conditional approach, which "turns off" the hedge whenever foreign interest rate is higher than the domestic one, predicting foreign currency appreciation. The conditional approach for the unitary, universal, and minimum variance strategy is constructed using both nominal and real interest rate differential.

4.1 Full Sample Findings

Our main findings are presented in the Table IV. We find that for all observed countries except Canada conditional approach outperforms the unconditional one for all three currency hedging strategies, yielding higher risk-adjusted returns. Sharpe ratios of conditionally hedged equity portfolios also outperform those of unhedged portfolios, suggesting that hedging may possibly be a "free lunch" if correctly timed to the periods of foreign currency depreciation.

Our results on Canada deviate from the general findings. As displayed in the Table IV, for a Canada-based equity investor conditional approach outperforms unconditional for the unitary and universal hedge, while

Table IV. Global Equity Portfolio Performance under Various Hedging Strategies.
(1980:07 – 2016:12)

	USA	*Germany*	*Canada*	*Switzerland*	*UK*	*Japan*	*Australia*
Unhedged Portfolio							
Average returns	11.29%	11.43%	11.37%	10.07%	13.19%	9.74%	12.64%
St. deviation	15.42%	15.37%	13.00%	16.50%	15.07%	17.77%	13.30%
Sharpe ratio	*0.40*	*0.42*	*0.35*	*0.41*	*0.35*	*0.39*	*0.27*
Unitary Hedge							
Average returns	10.31%	10.05%	11.97%	8.44%	13.21%	7.80%	14.47%
St. deviation	13.40%	13.34%	13.41%	13.32%	13.44%	13.50%	13.55%
Sharpe ratio	*0.38*	*0.39*	*0.39*	*0.38*	*0.39*	*0.36*	*0.40*
Conditional Unitary Hedge (nominal i.r.)							
Average returns	12.15%	12.09%	12.99%	10.72%	14.49%	10.09%	14.93%
St. deviation	14.75%	15.01%	13.27%	16.04%	13.91%	17.42%	13.41%
Sharpe ratio	*0.47*	*0.48*	*0.47*	*0.46*	*0.47*	*0.41*	*0.43*
Conditional Unitary Hedge (real i.r.)							
Average returns	12.17%	11.57%	12.45%	10.92%	14.50%	10.13%	14.47%
St. deviation	14.79%	14.75%	13.23%	15.85%	13.98%	16.62%	13.09%
Sharpe ratio	*0.47*	*0.45*	*0.43*	*0.48*	*0.47*	*0.43*	*0.41*
Universal Hedge							
Average returns	10.63%	10.67%	11.94%	8.60%	14.11%	7.27%	13.89%
St. deviation	13.76%	13.74%	13.26%	13.97%	13.72%	14.42%	13.43%
Sharpe ratio	*0.40*	*0.42*	*0.39*	*0.37*	*0.45*	*0.30*	*0.36*
Conditional Universal Hedge (nominal i.r.)							
Average returns	12.09%	12.22%	12.78%	10.75%	14.88%	9.93%	14.38%
St. deviation	14.88%	15.18%	13.20%	16.18%	14.16%	17.51%	13.35%
Sharpe ratio	*0.46*	*0.48*	*0.46*	*0.46*	*0.49*	*0.40*	*0.40*
Conditional Universal Hedge (real i.r.)							
Average returns	11.94%	11.79%	12.27%	10.61%	14.51%	9.62%	14.06%
St. deviation	14.93%	15.00%	13.17%	16.04%	14.14%	17.01%	13.17%
Sharpe ratio	*0.45*	*0.46*	*0.42*	*0.45*	*0.47*	*0.40*	*0.38*
Minimum Variance Hedge							
Average returns	10.40%	10.12%	11.32%	9.03%	13.22%	8.05%	13.74%
St. deviation	12.36%	12.11%	12.30%	12.08%	12.18%	12.28%	12.49%
Sharpe ratio	*0.42*	*0.43*	*0.37*	*0.47*	*0.43*	*0.42*	*0.37*
Conditional Minimum Variance Hedge (nominal i.r.)							
Average returns	12.66%	12.33%	10.86%	11.74%	14.55%	10.00%	14.08%
St. deviation	13.84%	13.90%	12.61%	15.90%	12.65%	16.50%	12.41%
Sharpe ratio	*0.54*	*0.53*	*0.32*	*0.53*	*0.52*	*0.43*	*0.40*
Conditional Minimum Variance Hedge (real i.r.)							
Average returns	11.99%	11.75%	10.87%	11.86%	13.53%	9.27%	13.44%
St. deviation	13.99%	13.49%	12.27%	15.42%	12.74%	15.46%	12.51%
Sharpe ratio	*0.49*	*0.51*	*0.33*	*0.55*	*0.44*	*0.41*	*0.35*

yields lower Sharpe ratio for the minimum variance strategy. We also observe that, compared to unhedged portfolio performance, full and universal hedging increase portfolio returns together with volatility in both unconditional and conditional approaches. Hence, the outcome of these strategies does not conform to the common effect of risk management. The minimum variance strategies, on the other hand, have resulted in lower portfolio volatility, but also in lower average returns, even with the conditional approach.

The findings on the USA, Germany, Switzerland, and Japan indicate that investors in these countries mostly did not benefit from unconditional hedging over the sample period because these strategies cut positive currency excess returns, which investors could have benefited from. For the minimum variance hedge, where the Sharpe ratios are slightly higher when compared to unhedged portfolio performance, the result is attributed to optimization of portfolio volatility as the obtained returns are lower than those of the unhedged portfolio. All conditional hedging strategies, on the other hand, achieved higher portfolio returns and lower standard deviations, outperforming both unconditional strategies and the zero hedge.

Another noteworthy result is Australia-based portfolio performance. Particularly, our findings show that the highest risk-adjusted returns for an Australian investor are achieved with unitary conditional and unconditional strategies. The benefit of full hedging over other strategies can be explained by negative excess returns on all six foreign currencies observed for Australia over the studied sample period (see Table II).

Therefore, our out-of-sample results indicate that over the period from 1980 to 2016 investors based in the USA, Germany, Switzerland, UK, Japan, and Australia could have increased their portfolio returns and lowered volatility by hedging their foreign currency risk with the proposed conditional approach. Based on the seven countries' average results, conditional hedging has improved the Sharpe ratio from 0.38 to 0.46 for the unitary strategy, from 0.38 to 0.45 for the universal strategy, and from 0.42 to 0.47 for the minimum variance strategy.

Considering the usage of nominal versus real interest rate differential as a hedging signal for conditional strategies, the findings indicate that for most countries nominal interest rates resulted in a slightly better Sharpe ratio

performance. The analysis of the forecasting accuracy of the employed interest rate differentials will be discussed later.

Further, we test whether the improvements of Sharpe ratios between conditional and unconditional approaches for the three hedging strategies are statistically significant. We employ the Sharpe ratio difference test proposed by Opdyke (2007) and use monthly, non-annualized data. Table V reports the results.

Table V. Differences of Sharpe Ratios between Conditional and Unconditional Strategies.
(1980:07 – 2016:12)

	USA	*Germany*	*Canada*	*Switzerland*	*UK*	*Japan*	*Australia*
Conditional Unitary vs. Unitary							
(nominal i.r.)							
SR difference	0.0231	0.0239	0.0208	0.0200	0.0199	0.0104	0.0096
1-tailed p-value:							
SRb - SRa ≤ 0	0.1298	0.1197	0.1471	0.1881	0.1487	0.3577	0.3115
(real i.r.)							
SR difference	0.0231	0.0171	0.0109	0.0248	0.0196	0.0166	0.0036
1-tailed p-value:							
SRb - SRa ≤ 0	0.1456	0.1945	0.2929	0.1262	0.1713	0.2685	0.4279
Conditional Universal vs. Universal							
(nominal i.r.)							
SR difference	0.0176	0.0159	0.0171	0.0213	0.0101	0.0241	0.0099
1-tailed p-value:							
SRb - SRa ≤ 0	0.1745	0.1995	0.1836	0.1340	0.3008	0.1474	0.2923
(real i.r.)							
SR difference	0.0145	0.0098	0.0073	0.0200	0.0036	0.0227	0.0052
1-tailed p-value:							
SRb - SRa ≤ 0	0.2307	0.2968	0.3491	0.1381	0.4272	0.1493	0.3878
Conditional Min.Var. vs. Min.Var.							
(nominal i.r.)							
SR difference	0.0302	0.0263	-0.0121	0.0139	0.0226	-0.0010	0.0076
1-tailed p-value:							
SRb - SRa ≤ 0	0.1996	0.2102	0.6791	0.3699	0.1848	0.5082	0.3515
(real i.r.)							
SR difference	0.0162	0.0196	-0.0092	0.0203	0.0014	-0.0051	-0.0063
1-tailed p-value:							
SRb - SRa ≤ 0	0.3239	0.2650	0.6325	0.2985	0.4806	0.5449	0.6233

One-tailed p-values indicate that the improvements in Sharpe ratios achieved by conditional hedging are not statistically significant. This outcome can be attributed to considerable estimation errors in mean returns. Section V will discuss the possible problems which could have driven and amplified those errors.

In the meantime, we take an overview of how the conditional hedging performed under various economic conditions within the studied timeframe. For this purpose we have divided the full sample into three sub-sample periods, each covering twelve years.

4.2 Sub-Sample Findings

The first sub-sample starts from 1980:07 and ends in 1992:12. The given period is marked by global economic recessions and captures the UK's "Black Wednesday" event: the sharp devaluation of pound sterling on September 17, 1992 as a result of failed attempts of British government to resist international currency speculation. Table VI presents the results of unhedged and hedged international stock portfolio performance for the given sub-sample.

The findings show that for investors based in the US, Germany, Switzerland, and the UK conditional currency hedging not only lowered portfolio volatility in the given time period, but also increased returns, outperforming the unhedged portfolio and all other hedging strategies. Similarly, the conditional approach yielded higher Sharpe ratios than the unconditional one for all hedging strategies for the Australia-based equity portfolio, allowing the investors to sustain their portfolio returns with the lower level of risk.

For the Canadian investor, the conditional minimum variance strategy was not successful in the given sub-sample, performing approximately on the same level as the zero hedge and worse than the unconditional minimum variance strategy. Given that the conditional approach performed very well in terms of Sharpe ratios both in the full and universal strategies, the weak results in the minimum variance strategy can be explained by errors in estimating hedging weights.

For Japan every hedging alternative outperformed the unhedged portfolio – an anticipated result, considering negative excess returns on foreign currencies in relation to yen (see Table A.2, sub-sample 1980:07-1992:12 in the Appendix A). Comparing the conditional versus the unconditional approach, conditional hedging did not provide a considerable benefit for the unitary and the universal strategy, but outperformed constant hedging for the minimum variance strategy.

Overall, we observe that during 1980's and the beginning of 1990's conditional approach had advantage over the unconditional for five out of seven

Table VI. Sub-sample 1: Global Equity Portfolio Performance under Various Hedging Strategies.
(1980:07 – 1992:12)

	USA	*Germany*	*Canada*	*Switzerland*	*UK*	*Japan*	*Australia*
Unhedged Portfolio							
Average returns	14.41%	13.87%	15.17%	13.80%	18.65%	9.50%	20.78%
St. deviation	15.46%	16.56%	14.55%	17.07%	15.89%	16.38%	16.31%
Sharpe ratio	*0.31*	*0.40*	*0.26*	*0.46*	*0.38*	*0.19*	*0.38*
Unitary Hedge							
Average returns	14.20%	11.87%	16.17%	10.43%	17.45%	11.55%	19.90%
St. deviation	13.97%	13.91%	13.98%	13.90%	14.04%	14.60%	14.39%
Sharpe ratio	*0.33*	*0.33*	*0.34*	*0.32*	*0.35*	*0.35*	*0.37*
Conditional Unitary Hedge (nominal i.r.)							
Average returns	15.95%	15.03%	17.83%	14.74%	19.88%	10.93%	20.44%
St. deviation	14.58%	16.02%	14.12%	16.39%	14.37%	16.17%	14.54%
Sharpe ratio	*0.44*	*0.48*	*0.45*	*0.54*	*0.51*	*0.28*	*0.40*
Conditional Unitary Hedge (real i.r.)							
Average returns	16.57%	14.25%	17.66%	14.51%	20.06%	12.07%	20.42%
St. deviation	14.60%	15.80%	14.08%	16.49%	14.27%	15.94%	14.15%
Sharpe ratio	*0.48*	*0.44*	*0.44*	*0.52*	*0.52*	*0.35*	*0.41*
Universal Hedge							
Average returns	13.44%	13.18%	15.36%	12.12%	18.57%	10.37%	19.54%
St. deviation	14.37%	14.41%	13.99%	14.46%	14.23%	14.76%	14.71%
Sharpe ratio	*0.27*	*0.41*	*0.28*	*0.43*	*0.42*	*0.27*	*0.34*
Conditional Universal Hedge (nominal i.r.)							
Average returns	15.26%	15.30%	16.95%	15.11%	20.21%	10.46%	20.29%
St. deviation	14.91%	14.96%	14.91%	14.92%	14.92%	14.88%	14.84%
Sharpe ratio	*0.38*	*0.54*	*0.37*	*0.62*	*0.51*	*0.27*	*0.39*
Conditional Universal Hedge (real i.r.)							
Average returns	15.52%	14.81%	16.89%	14.73%	20.18%	11.18%	20.11%
St. deviation	14.88%	14.93%	14.88%	14.89%	14.89%	14.84%	14.79%
Sharpe ratio	*0.40*	*0.50*	*0.37*	*0.59*	*0.51*	*0.32*	*0.38*
Minimum Variance Hedge							
Average returns	14.99%	13.21%	16.58%	11.96%	18.43%	10.56%	20.83%
St. deviation	14.46%	14.11%	14.37%	13.99%	14.21%	14.76%	14.87%
Sharpe ratio	*0.38*	*0.42*	*0.36*	*0.43*	*0.41*	*0.28*	*0.42*
Conditional Minimum Variance Hedge (nominal i.r.)							
Average returns	17.37%	14.74%	15.52%	16.77%	19.34%	12.24%	21.26%
St. deviation	14.90%	16.03%	14.22%	16.29%	14.29%	16.27%	14.79%
Sharpe ratio	*0.52*	*0.47*	*0.29*	*0.67*	*0.47*	*0.36*	*0.45*
Conditional Minimum Variance Hedge (real i.r.)							
Average returns	18.04%	15.26%	14.90%	16.31%	19.01%	13.09%	20.99%
St. deviation	14.79%	15.31%	13.95%	16.32%	13.97%	16.15%	14.83%
Sharpe ratio	*0.57*	*0.52*	*0.25*	*0.64*	*0.46*	*0.41*	*0.43*

studied countries. For the other two – namely, Canada and Japan – conditional currency hedging succeeded for some strategies, while failed for others. Nonetheless, one should be careful drawing any definite conclusions from the presented numbers, as the Sharpe ratio difference tests did not provide statistically significant results. For Sharpe ratio differences and p-values for all three sub-samples refer to the Appendix B.

The second sub-sample encompasses the period from 1993 until the end of 2004. These years witnessed the Asian currency crisis of 1997, but, aside from that, the period was relatively stable and was marked by the adoption of the Euro currency in 1999. Table VII reports the findings.

Comparing with the previous sub-sample, for the given period one can easily notice a higher overall risk-adjusted return performance of the unhedged and hedged global stock portfolios. The higher Sharpe ratios are mostly attributed to the decrease of interest rates in all observed countries (see Table 1.A in the Appendix A).

As in the previous period, the conditional currency hedging has resulted in lower volatility and higher portfolio returns for investors based in the USA, Germany, and Switzerland. Similarly, in Canada the conditional approach succeeded in full and universal hedging strategies. However, the performance of the minimum variance hedge, both unconditional and conditional, was worse than not hedging at all due to minor volatility improvements and substantial cuts of returns.

For the UK-based portfolio, hedging in the given period was highly beneficial considering negative excess returns on all six foreign currencies. For Japan the opposite was true: the country had positive currency excess returns and, thus, unhedged portfolio, which maintained the beneficial exposure to foreign currencies, resulted in higher Sharpe ratio than unconditional hedging strategies.

For the Australian investor, the conditional approach outperformed both the unconditional one and the zero hedge. However, in cases of unitary and universal strategies higher achieved returns were accompanied by increased risk.

Overall, for the second sub-sample we observe that for four out of seven countries conditional hedging yielded the highest risk-adjusted returns comparing

Table VII. Sub-sample 2: Global Equity Portfolio Performance under Various Hedging Strategies.

(1993:01 – 2004:12)

	USA	*Germany*	*Canada*	*Switzerland*	*UK*	*Japan*	*Australia*
Unhedged Portfolio							
Average returns	11.92%	11.22%	11.17%	10.17%	9.95%	10.44%	10.45%
St. deviation	14.00%	16.13%	12.39%	17.22%	15.21%	15.99%	11.82%
Sharpe ratio	*0.55*	*0.45*	*0.54*	*0.46*	*0.28*	*0.61*	*0.41*
Unitary Hedge							
Average returns	10.82%	10.52%	11.00%	8.61%	12.38%	7.09%	12.26%
St. deviation	13.16%	13.12%	13.15%	13.08%	13.18%	13.11%	13.15%
Sharpe ratio	*0.50*	*0.50*	*0.50*	*0.49*	*0.51*	*0.48*	*0.51*
Conditional Unitary Hedge (nominal i.r.)							
Average returns	13.72%	12.31%	12.48%	10.66%	12.85%	10.65%	13.07%
St. deviation	13.48%	14.98%	12.70%	16.34%	13.45%	15.97%	12.55%
Sharpe ratio	*0.70*	*0.56*	*0.63*	*0.52*	*0.53*	*0.62*	*0.60*
Conditional Unitary Hedge (real i.r.)							
Average returns	13.89%	12.15%	11.73%	11.23%	12.43%	10.35%	12.29%
St. deviation	13.69%	14.73%	12.73%	16.16%	13.29%	15.58%	12.05%
Sharpe ratio	*0.70*	*0.56*	*0.57*	*0.56*	*0.51*	*0.62*	*0.56*
Universal Hedge							
Average returns	11.70%	10.80%	11.75%	8.62%	12.57%	6.35%	11.64%
St. deviation	13.17%	13.82%	13.03%	13.98%	13.54%	13.79%	12.81%
Sharpe ratio	*0.57*	*0.49*	*0.56*	*0.46*	*0.51*	*0.41*	*0.47*
Conditional Universal Hedge (nominal i.r.)							
Average returns	13.72%	12.31%	12.61%	10.54%	12.81%	10.42%	12.38%
St. deviation	13.45%	15.34%	12.63%	16.56%	13.76%	15.98%	12.41%
Sharpe ratio	*0.70*	*0.54*	*0.65*	*0.50*	*0.52*	*0.61*	*0.55*
Conditional Universal Hedge (real i.r.)							
Average returns	13.93%	12.24%	11.98%	10.88%	12.53%	9.98%	11.94%
St. deviation	13.69%	15.13%	12.67%	16.40%	13.63%	15.73%	12.11%
Sharpe ratio	*0.71*	*0.55*	*0.60*	*0.53*	*0.50*	*0.59*	*0.52*
Minimum Variance Hedge							
Average returns	9.97%	10.17%	9.78%	8.81%	11.89%	6.74%	10.71%
St. deviation	11.46%	11.34%	11.51%	11.25%	11.32%	11.47%	11.52%
Sharpe ratio	*0.50*	*0.55*	*0.47*	*0.59*	*0.55*	*0.52*	*0.44*
Conditional Minimum Variance Hedge (nominal i.r.)							
Average returns	15.04%	13.33%	9.77%	13.33%	12.24%	11.26%	11.23%
St. deviation	12.16%	13.36%	12.08%	15.10%	11.56%	15.95%	11.34%
Sharpe ratio	*0.89*	*0.70*	*0.44*	*0.74*	*0.56*	*0.66*	*0.50*
Conditional Minimum Variance Hedge (real i.r.)							
Average returns	13.21%	11.27%	10.72%	14.55%	12.35%	9.47%	10.87%
St. deviation	13.04%	13.03%	11.79%	14.87%	11.40%	15.11%	11.35%
Sharpe ratio	*0.69*	*0.56*	*0.53*	*0.83*	*0.58*	*0.58*	*0.46*

to all other observed alternatives, and for the three other countries it performed better in certain strategies.

The third sub-sample extends from 2005 until the end of 2016 and captures the global financial crisis. The performance of the hedging strategies for the given sub-sample are presented in the Table VIII.

We observe that the average risk-adjusted return performance in 2005-2016 was the lowest among the three sub-sample periods. Such results were primarily due to lower stock performance during the global financial crisis and the years following it.

The results of the Table VIII indicate that the performance of the conditional strategies was not as good and consistent as in the previous periods. Compared to the unconditional full hedge, the conditional approach based on nominal interest rate differential failed to improve Sharpe ratios in the USA and Switzerland, and based on real interest rates – in the USA, Canada, and Australia. For universal strategies, the conditional nominal hedge did not yield improved results in the USA and Australia, while the conditional real hedge – in the USA, Canada, the UK, and Australia. This is a noticeable downgrade from the performance achieved in the first two sub-samples.

The poorest performance in the given period is observed for the conditional minimum variance hedge. The achieved lower portfolio returns indicate that the given strategy mostly cut currency excess returns instead of capturing them. Only Germany and the UK-based portfolios benefited from conditional minimum variance strategy.

Overall, we find that in the third sub-sample Germany is the only base country for which the conditional approach to hedging has outperformed the unconditional one for all hedging strategies. For the USA the conditional approach completely failed, while for other countries the results are highly inconsistent for making any conclusions. Hence, the third sub-sample has revealed the inability of our simple conditional strategies to produce consistently good performance during a major crisis. This vulnerability most likely stems from the difficulty to correctly forecast future exchange rate movements and capture true correlations during the times of economic instability.

Table VIII. Sub-sample 3: Global Equity Portfolio Performance under Various Hedging Strategies.
(2005:01 – 2016:12)

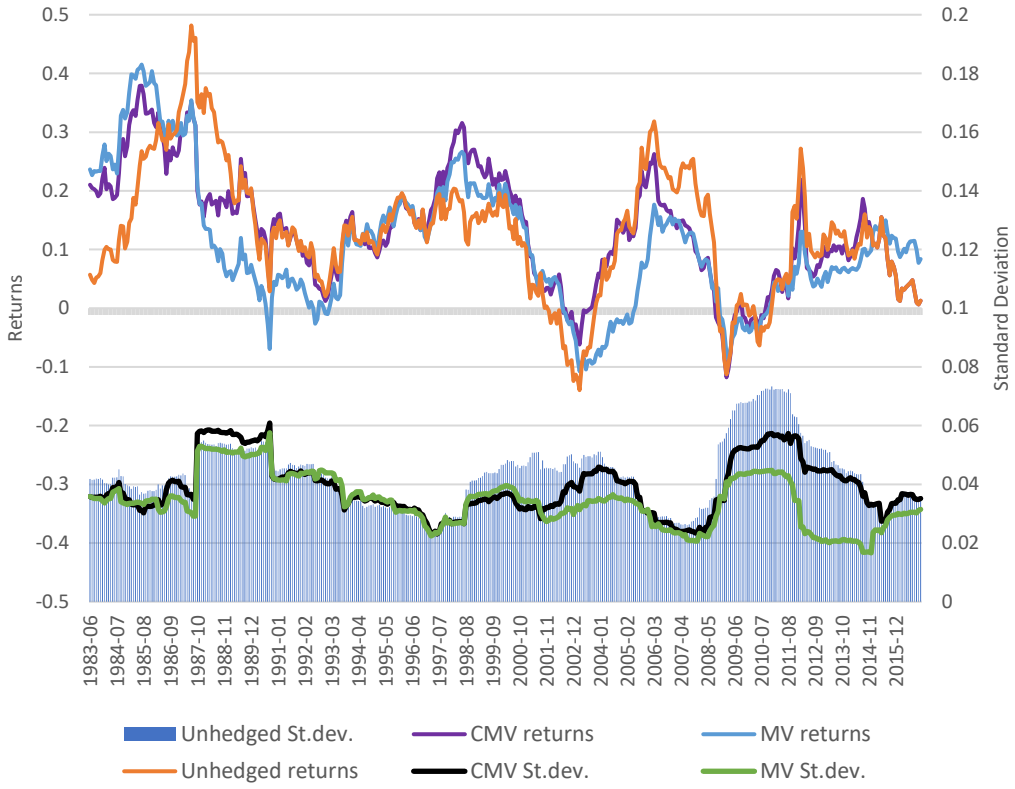
	USA	*Germany*	*Canada*	*Switzerland*	*UK*	*Japan*	*Australia*
Unhedged Portfolio							
Average returns	7.48%	9.13%	7.70%	6.19%	10.92%	9.24%	7.10%
St. deviation	16.75%	13.20%	11.83%	15.15%	14.01%	20.44%	10.99%
Sharpe ratio	*0.35*	*0.43*	*0.29*	*0.28*	*0.40*	*0.38*	*0.01*
Unitary Hedge							
Average returns	5.87%	7.71%	8.66%	6.21%	9.72%	5.65%	11.46%
St. deviation	13.02%	13.00%	13.06%	13.02%	13.06%	13.03%	13.06%
Sharpe ratio	*0.33*	*0.33*	*0.33*	*0.33*	*0.34*	*0.33*	*0.34*
Conditional Unitary Hedge (nominal i.r.)							
Average returns	6.79%	8.84%	8.59%	6.69%	10.67%	8.88%	11.46%
St. deviation	16.09%	13.95%	12.90%	15.41%	13.87%	19.72%	13.06%
Sharpe ratio	*0.32*	*0.39*	*0.33*	*0.31*	*0.39*	*0.38*	*0.34*
Conditional Unitary Hedge (real i.r.)							
Average returns	6.08%	8.27%	7.92%	6.95%	10.94%	8.41%	10.92%
St. deviation	15.96%	13.67%	12.76%	14.86%	14.32%	18.18%	12.95%
Sharpe ratio	*0.28*	*0.36*	*0.28*	*0.34*	*0.39*	*0.39*	*0.30*
Universal Hedge							
Average returns	6.70%	7.98%	8.63%	4.98%	11.11%	5.82%	10.70%
St. deviation	13.72%	12.98%	12.73%	13.47%	13.35%	14.83%	12.65%
Sharpe ratio	*0.37*	*0.35*	*0.34*	*0.23*	*0.43*	*0.30*	*0.29*
Conditional Universal Hedge (nominal i.r.)							
Average returns	7.27%	8.99%	8.73%	6.54%	11.57%	9.02%	10.70%
St. deviation	16.20%	13.85%	12.67%	15.34%	14.04%	19.88%	12.65%
Sharpe ratio	*0.35*	*0.40*	*0.35*	*0.30*	*0.44*	*0.38*	*0.29*
Conditional Universal Hedge (real i.r.)							
Average returns	6.37%	8.25%	7.89%	6.16%	10.75%	8.05%	10.36%
St. deviation	16.08%	13.68%	12.53%	15.04%	14.14%	18.96%	12.69%
Sharpe ratio	*0.30*	*0.36*	*0.29*	*0.28*	*0.38*	*0.35*	*0.27*
Minimum Variance Hedge							
Average returns	6.19%	6.93%	7.53%	6.26%	9.26%	7.44%	10.00%
St. deviation	10.69%	10.51%	10.56%	10.69%	10.57%	10.93%	10.58%
Sharpe ratio	*0.43*	*0.34*	*0.31*	*0.40*	*0.37*	*0.55*	*0.28*
Conditional Minimum Variance Hedge (nominal i.r.)							
Average returns	5.63%	8.88%	7.21%	5.15%	11.99%	7.03%	10.07%
St. deviation	14.18%	11.94%	11.25%	16.22%	11.85%	17.29%	10.58%
Sharpe ratio	*0.28*	*0.46*	*0.26*	*0.20*	*0.56*	*0.33*	*0.29*
Conditional Minimum Variance Hedge (real i.r.)							
Average returns	4.79%	8.65%	6.93%	4.80%	9.19%	6.16%	8.81%
St. deviation	13.94%	11.85%	10.75%	14.90%	12.63%	15.30%	10.87%
Sharpe ratio	*0.23*	*0.44*	*0.24*	*0.19*	*0.31*	*0.31*	*0.17*

Section V. Analysis of Results

5.1 Performance of Conditional versus Unconditional Hedge

The graph below (Graph 1) provides a visual representation of the conditional minimum variance hedge performance of the US-based stock portfolio against the unconditional and the zero hedge strategy. The left-hand-side axis corresponds to the returns, while the right-hand-side axis – to standard deviations. The data is based on 36-months moving averages.

Graph 1. Performance of the US-based Portfolio: Conditional and Unconditional Minimum Variance Strategy.



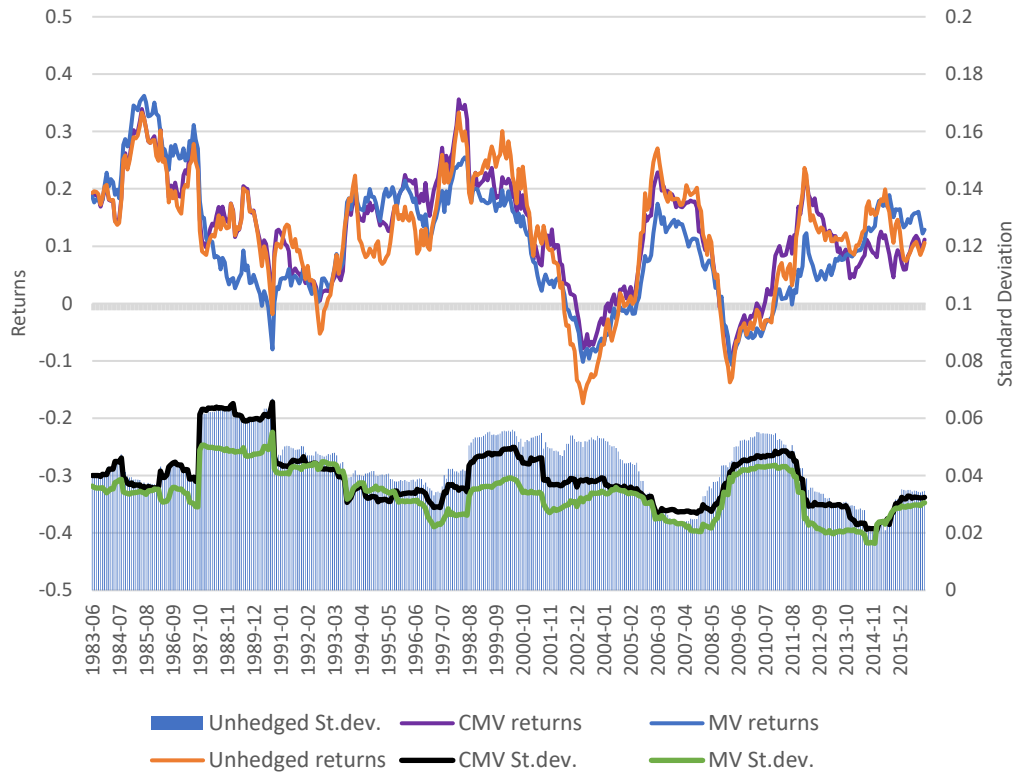
The graph shows that the conditional strategy clearly outperformed the simple minimum variance hedge in terms of returns. This result provides supporting evidence to the idea that the conditional approach is capable of addressing the problem of unconditional hedging, – namely, preserve currency returns which plain hedging strategies cut off. Comparing the conditional approach with the performance of the unhedged portfolio, one can see that, on average, the returns obtained from conditional hedging followed the unhedged returns and during some periods outperformed them. Several periods of

underperformance point toward the presence of certain problems within the conditional strategy and the potential of improving it.

From the standpoint of volatility reduction, the US-based investor benefited from currency hedging mostly in the second half of the sample period and especially during the global financial crisis and the years following it. The lowest volatility of portfolio returns was achieved with the simple minimum variance strategy. The standard deviation of the conditionally hedged returns was slightly higher, yet, compared to the zero hedge, the conditional approach provided a minor benefit.

The performance of the conditional strategy for a German investor is shown on the Graph 2.

Graph 2. Performance of the Germany-based Portfolio: Conditional and Unconditional Minimum Variance Strategy.



One can see that for the German investor conditional currency hedging yielded returns equivalent to those obtained by the unhedged portfolio, yet with lower volatility, providing a higher risk-adjusted return benefit. For the visualized results of the unitary and universal conditional strategies for the US and Germany-based portfolios please refer to the Appendix C.

Up to this point, we have mostly focused on the attractiveness of the conditional strategy, which was the main finding of our research. Yet, keeping in mind the lack of significance in the improvements of Sharpe ratios and the poor results of the third sub-sample, we find it important to discuss the possible problems which have affected our results and look into the ways how the proposed simple conditional hedging strategy can be improved.

5.2 Predicting Power of Interest Rate Differentials

The predicting tool is one of the key success determinants of conditional hedging because the correct forecast of movements in foreign exchange rates allows to turn the hedge "on" and "off" at correct times. Having measured the frequency of correct and incorrect signals over the full studied period, we find that the real interest rate differential has on average correctly predicted 51.57% of subsequent exchange rate movements, and the predicting accuracy of nominal interest rate differential was 51.60%. The average forecasting power was higher during the first and the second sub-sample: 52.67% with real rates and 52.59% with nominal, and lower in the third sub-sample: 49.31% and 49.57% respectively. Table IX provides the forecasting accuracy for portfolios based in each of the seven countries.

Table IX. Forecasting Accuracy of Interest Rate Differentials.

	USA	*Germany*	*Canada*	*Switzerland*	*UK*	*Japan*	*Australia*
Nominal interest rates							
Sub-sample 1 and 2	54.88%	51.53%	53.17%	52.04%	50.91%	54.25%	51.36%
Sub-sample 3	46.41%	49.42%	48.38%	48.50%	48.96%	52.66%	52.66%
Real interest rates							
Sub-sample 1 and 2	55.27%	51.42%	52.89%	52.44%	51.47%	54.54%	50.68%
Sub-sample 3	45.49%	48.84%	48.84%	50.12%	48.26%	52.08%	51.50%

Overall, based on the data in the Table IX, we find that the interest rate differential was a weak predicting tool. Its forecasting accuracy was especially low for the USA during the sub-sample capturing the financial crisis. Consequently, the interest rate differential frequently sent false signals, making the conditional strategy employ the hedge when currency excess returns were positive and withdraw from hedging when currency exposure was unprofitable.

Next, we have tested whether the interest rate differential was more successful at predicting bigger movements and failed when the movements were

small. The results deny this idea, showing that the average movement in exchange rates (measured in absolute values) for correct and incorrect predictions was similar: 2.19% for correct and 2.37% for incorrect predictions.

Given the low accuracy of the employed forecasting tool, it is surprising that our conditional strategy performed relatively well. Apparently, the gains from correct predictions exceeded the losses incurred by the wrong signals. To provide the evidence, we take the US-based conditional unitary strategy, which is free from possible hedging estimation errors, and divide its currency returns into two groups – those, which were achieved as a result of correct forecast from the interest rate differential, and those, which resulted from incorrect predictions. Table X presents the results.

Table X. Currency Returns from Correct and Incorrect Predictions for the US-based Global Stock Portfolio.
(1980:07 – 2016:12)

	% of correct predictions	Avg. returns on correct predictions	Avg. returns on incorrect predictions	Avg. monthly returns	Annualized returns
Conditional Unitary (nominal i.r.)	51.72%	1.30%	-1.18%	0.10%	1.20%
Conditional Unitary (real i.r.)	51.68%	1.53%	-1.43%	0.10%	1.24%
Unhedged (assume currencies only appreciate)	49.55%	2.33%	-2.21%	0.04%	0.50%
Unitary (assume currencies only depreciate)	50.45%	-0.04%	-0.08%	-0.06%	-0.71%
Perfectly Correct Hedge	100.00%	1.14%	0.00%	1.14%	14.47%

One can see that for the conditional unitary strategy currency gains from correct forecasts exceeded the losses by, on average, 0.10% per month, or 1.22% annually. The results of zero and full hedge show that the conditional approach, despite its week predictability, outperformed the hypothetical naïve assumptions that currencies will only appreciate/depreciate. In the last row of the Table X we present the performance which could have been achieved with a "perfect conditional hedge" – the one, which had 100% forecasting accuracy. Of course, this strategy is far from reality. Yet, it reveals the enormous return potential of the conditional approach to currency hedging.

The way to address the problem of poor predictability of our conditional strategy is to look into other possible forecasting indicators of exchange rate movements. The study of Rossi (2013), for example, provides an empirical evaluation of in- and out-of-sample performance of several classic and more

recent forecasting models by comparing them against the random walk. For one-month predictions Rossi finds that the forecasting power of most models disappears in out-of-sample tests. Fundamentals model, which is based on a Taylor rule, is found to be the only one which persists, yet does not systematically beat random walk across all countries and time periods. The model was able to produce significant estimates for the US exchange rates relative to Canada, Germany, and Japan.

The complication of using the Taylor-rule fundamentals model for out-of-sample forecasts lies in availability of its data inputs (GDP, employment, inflation), which are observed and reported only post-factum. Therefore, one has to rely on separate models to predict input variables, which adds complexity and estimation errors to the forecast.

Alternatively, another exchange rate forecasting model is proposed by Evans and Lyons (2002, 2005) and is based on an order flow. The empirical findings show that the order flow model "explain[s] exchange rate movements for periods up to one month and provide[s] out-of-sample forecasts that outperform both standard macroeconomic models and a random walk" (Bailliu & King, 2005, p.34).

The mentioned forecasting models are provided as suggestions for further steps towards the improved conditional strategy. Given the attractive performance of conditional hedging with only 51.6% forecasting accuracy of the employed interest rate differentials, we perceive that even minor improvements in a forecasting indicator can provide a considerable payoff.

5.3 Estimation Error in Hedging Weights

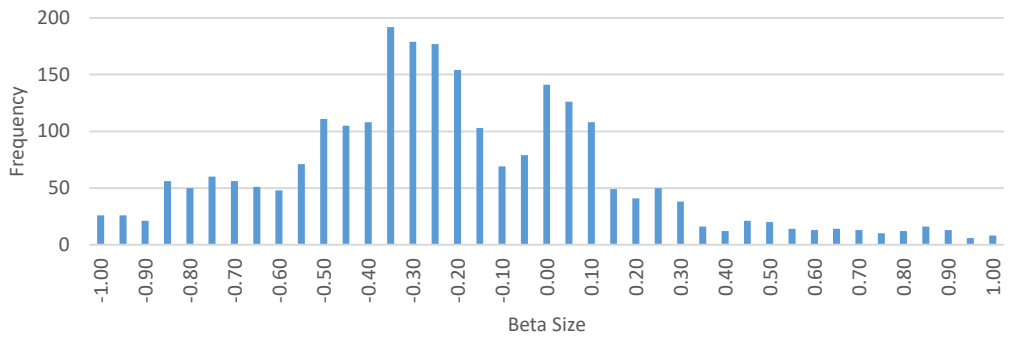
The second problem which has likely affected the research findings and the significance of its results is errors in estimating hedging weights. This problem is relevant for universal and minimum variance strategies.

The factor which most clearly indicates on the given issue is the standard deviations achieved by the minimum variance and the full hedge strategy in the first sub-sample period (see Table VI). Both strategies enter into a hedge at the same time – either constantly for the unconditional approach, or based on the same interest rate differential. Their only distinction is hedging weights. Yet, we find that in the first sub-sample the minimum variance strategy, unconditional and

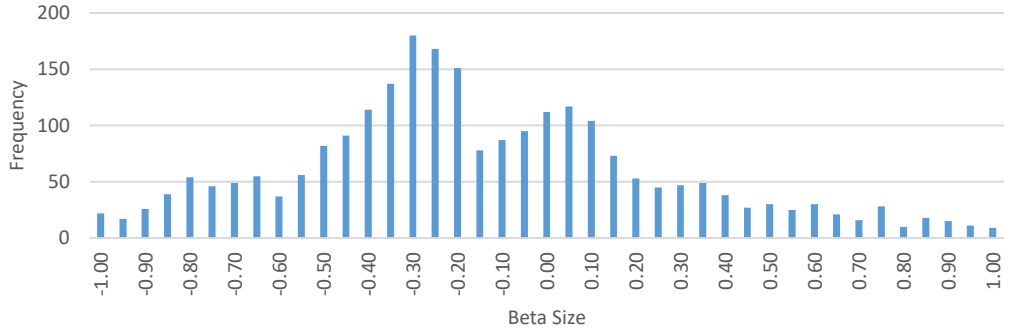
conditional, has resulted in higher volatility than the unitary strategy. These results suggest that the weights obtained through volatility optimization during the given period were, in fact, sub-optimal: affected by estimation errors.

Another way to look into the potential problem with weights estimation is to observe the distribution of betas. Graphs 3 and 4 depict the distribution of hedging weights from -1 to 1 for the minimum variance strategy for the US- and Germany-based portfolios over the full sample period.

Graph 3. Distribution of the Minimum Variance Hedging Weights for the US-based Portfolio.



Graph 4. Distribution of the Minimum Variance Hedging Weights for the Germany-based Portfolio.



The graphs reveal that a considerable number of betas were close to zero – representing weak relationships captured by regressions. There is a possibility that those relationships were, in fact, too weak to provide a basis for a meaningful hedge. Consequently, hedging positions employing those close-to-zero betas could have added noise to the findings and weakened our results.

One of the ways to address the given problem and reduce the estimation errors in hedging weights is proposed by Goto & Xu (2015). Their method

employs a graphical lasso (glasso) algorithm, which shrinks the estimated hedging weights by filtering certain factors. The given glasso estimator is sparse, meaning that a significant fraction of its off-diagonal elements are 0. The findings of Goto & Xu (2015) show that "the proposed glasso estimator of the inverse covariance matrix [effectively mitigates the estimation errors and] accomplishes a significant and robust out-of-sample risk reduction" (p. 1438-1439). Implementation of the given algorithm was out of scope of this study, which focused on the simplest version of conditional currency hedging. Yet, we suggest to consider this tool or a similar method of improving hedge estimators in future research on conditional unitary and minimum variance strategies.

5.4 Implications to Investors

Finally, we ponder what practical implications our findings have for an investor. As mentioned earlier, the common unconditional currency hedging strategies offer the investor significant risk reduction benefits, yet lower his portfolio returns.

Our findings indicate that conditional hedging has managed to address the given problem by succeeding to capture currency excess returns in all hedging strategies and for all observed investors. The only exception in this regard was found in Canada-based minimum variance hedge.

In terms of hedging risk, our selective approach had varying success. For investors based in the UK, Canada, and Australia, conditional hedging has resulted in the same risk level as unconditional hedging, yet for the remaining countries the risk reduction benefit of the conditional approach was lower. Overall, looking at portfolio performance from the risk-adjusted return perspective, we conclude that conditional hedging can offer investors an advantage over plain hedging strategies.

The results of the study have also shown that, compared to zero hedge, conditional hedging can be a "free lunch". For those investors who are not particularly concerned about minimizing their currency risk and consider to leave their foreign equity holdings unhedged to sustain returns – conditional hedging can provide a highly attractive alternative.

Section VI. Conclusion

Previous in-sample (Campbell et. al., 2010) and out-of-sample (De Roon et. al., 2014) studies have documented that currency risk hedging strategies effectively reduce portfolio volatility. However, in the presence of currency excess returns, these strategies are not costless for global investors: hedging can result in significant losses of average portfolio returns (De Roon et. al., 2014). To address this problem, we have proposed a conditional approach to currency hedging – a strategy, which, based on a forecasting tool, times a hedge only to periods of foreign currency depreciation and allows investors to benefit from their natural currency exposure when foreign currencies appreciate.

The given out-of-sample study focused on a simple version of the conditional hedge and employed an interest rate differential as a forecasting indicator of future exchange rate changes. The purpose of the study was to test the performance of conditional currency hedging on internationally diversified stock portfolios and compare its Sharpe ratio results against those achieved by the commonly used unconditional risk hedging strategies: full, universal, and minimum-variance.

We have found that for six out of seven observed countries the conditional unitary, universal, and minimum variance strategies resulted in higher risk-adjusted return performance than the unconditional strategies, and for one country – Canada – conditional approach yielded superior performance in the unitary and universal strategies, while failed to succeed with the minimum variance hedge. Similarly, for all countries except Canada Sharpe ratios of conditionally hedged portfolios outperformed those of unhedged portfolios. However, the results of the study lack statistical significance and, therefore, cannot be a basis for making definite conclusions. Insignificance of the findings can be partially explained by poor and inconsistent performance of the conditional strategies during the global financial crisis, and also attributed to the weak forecasting power of the interest rate differential (51-52% accuracy) and to estimation errors in hedging weights.

The abovementioned problems indicate that the conditional strategy can be further strengthened and refined. Particularly, the recommendations for future research include improving the forecasting model the conditional strategy is based on and addressing the issue of estimation errors in the covariance matrix.

Overall, the given study has provided an important insight into the huge attractive potential of the conditional strategy, and concludes that, if correctly timed, conditional currency hedging may in fact be a “free lunch” for international equity investors.

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Appendix A

Sub-sample Summary Statistics

Table A.1. Sub-sample Interest Rates and Stock Returns.

1980:07 - 1992:12

	USA	*Germany*	*Canada*	*Switzerland*	*UK*	*Japan*	*Australia*
Nominal interest rates							
Average	9.56%	7.28%	11.44%	5.91%	12.60%	6.45%	14.56%
St. deviation	3.98%	2.68%	3.75%	2.42%	2.49%	1.74%	3.72%
Real interest rates							
Average	4.62%	4.24%	5.61%	2.23%	6.15%	4.09%	7.28%
St. deviation	2.56%	1.45%	2.21%	1.83%	2.52%	1.01%	2.77%
Excess stock returns in local currency							
Average	7.07%	5.75%	-2.55%	6.19%	7.54%	6.04%	1.05%
St. deviation	15.92%	20.50%	16.79%	16.87%	18.85%	20.27%	22.21%

1993:01 - 2004:12

	USA	*Germany*	*Canada*	*Switzerland*	*UK*	*Japan*	*Australia*
Nominal interest rates							
Average	4.25%	3.97%	4.42%	2.18%	5.71%	0.73%	5.59%
St. deviation	1.91%	1.57%	1.50%	1.51%	1.19%	1.01%	1.04%
Real interest rates							
Average	1.76%	2.22%	2.61%	1.13%	4.02%	0.63%	3.09%
St. deviation	1.81%	0.97%	1.87%	1.10%	1.11%	0.96%	1.51%
Excess stock returns in local currency							
Average	7.50%	7.45%	8.59%	10.65%	3.05%	0.42%	6.73%
St. deviation	14.77%	22.86%	16.24%	17.24%	13.62%	17.88%	12.77%

2005:01 - 2016:12

	USA	*Germany*	*Canada*	*Switzerland*	*UK*	*Japan*	*Australia*
Nominal interest rates							
Average	1.63%	3.37%	4.29%	1.94%	5.31%	1.40%	6.98%
St. deviation	1.98%	1.74%	2.59%	1.33%	3.09%	1.34%	2.09%
Real interest rates							
Average	-0.41%	1.97%	2.55%	1.63%	2.99%	1.15%	4.43%
St. deviation	1.71%	1.89%	2.86%	1.93%	3.92%	1.35%	2.51%
Excess stock returns in local currency							
Average	7.22%	6.99%	4.05%	5.29%	2.77%	5.01%	1.96%
St. deviation	14.31%	18.50%	13.30%	13.04%	13.39%	19.18%	13.81%

Table A.2. Sub-sample Currency Excess Returns for Investors Based in Each of the Observed Countries.

1980:07 - 1992:12

		USD	*EUR*	*CAD*	*CHF*	*GBP*	*JPY*	*AUD*
USA			-0.58%	1.02%	-1.59%	0.12%	2.52%	0.92%
	st.dev.		12.63%	4.50%	13.49%	13.19%	12.37%	10.68%
Germany		2.19%		3.11%	-1.00%	1.09%	3.69%	2.85%
	st.dev.	12.67%		12.54%	5.05%	9.55%	10.17%	14.80%
Canada		-0.81%	-1.51%		-2.51%	-0.87%	1.61%	-0.05%
	st.dev.	4.52%	12.46%		13.30%	12.56%	12.54%	10.23%
Switzerland		3.46%	1.27%	4.40%		2.30%	4.88%	4.12%
	st.dev.	13.48%	5.06%	13.35%		10.04%	10.28%	15.41%
UK		1.61%	-0.18%	2.47%	-1.24%		3.20%	2.13%
	st.dev.	13.20%	9.59%	12.61%	10.29%		11.77%	14.37%
Japan		-0.99%	-2.57%	-0.06%	-3.66%	-1.81%		-0.37%
	st.dev.	12.17%	10.06%	12.34%	10.21%	11.37%		14.25%
Australia		0.25%	-0.57%	1.12%	-1.60%	-0.02%	2.51%	
	st.dev.	11.02%	15.28%	10.49%	15.96%	14.69%	14.95%	

1993:01 - 2004:12

		USD	*EUR*	*CAD*	*CHF*	*GBP*	*JPY*	*AUD*
USA			1.14%	0.80%	0.61%	3.72%	-1.07%	2.84%
	st.dev.		9.57%	5.94%	10.31%	7.60%	12.17%	9.73%
Germany		-0.23%		0.46%	-0.53%	3.01%	-1.76%	2.35%
	st.dev.	9.56%		10.23%	3.74%	7.58%	12.02%	11.71%
Canada		-0.45%	0.58%		0.09%	3.22%	-1.60%	2.04%
	st.dev.	5.93%	10.21%		11.35%	9.25%	12.88%	8.00%
Switzerland		0.44%	0.67%	1.18%		3.70%	-1.18%	3.13%
	st.dev.	10.26%	3.74%	11.30%		8.42%	11.87%	12.99%
UK		-3.03%	-2.37%	-2.29%	-2.89%		-4.28%	-0.45%
	st.dev.	7.57%	7.56%	9.21%	8.34%		12.70%	10.82%
Japan		2.54%	3.22%	3.27%	2.59%	6.11%		5.20%
	st.dev.	11.91%	11.75%	12.59%	11.65%	12.38%		13.80%
Australia		-1.84%	-0.96%	-1.38%	-1.39%	1.64%	-3.12%	
	st.dev.	9.75%	11.68%	7.95%	13.05%	10.87%	13.92%	

2005:01 - 2016:12

		USD	*EUR*	*CAD*	*CHF*	*GBP*	*JPY*	*AUD*
USA			0.15%	2.15%	1.87%	0.34%	-0.61%	5.72%
	st.dev.		10.31%	9.94%	11.07%	9.23%	9.90%	13.48%
Germany		0.92%		2.51%	1.93%	0.68%	0.16%	5.61%
	st.dev.	10.44%		9.69%	7.74%	8.71%	13.51%	9.26%
Canada		-1.13%	-1.54%		0.34%	-1.28%	-1.70%	3.53%
	st.dev.	10.12%	9.72%		12.28%	9.36%	14.55%	9.56%
Switzerland		-0.65%	-1.35%	1.09%		-0.76%	-1.59%	4.10%
	st.dev.	11.01%	7.30%	11.76%		10.64%	12.35%	11.05%
UK		0.52%	0.10%	2.19%	1.96%		-0.02%	5.54%
	st.dev.	9.36%	9.02%	9.44%	11.21%		14.32%	11.52%
Japan		1.60%	1.59%	3.80%	3.13%	1.99%		7.31%
	st.dev.	9.96%	13.01%	13.99%	12.11%	13.77%		15.97%
Australia		-3.65%	-4.50%	-2.53%	-2.74%	-4.02%	-4.30%	
	st.dev.	13.83%	9.29%	9.59%	11.37%	11.31%	16.89%	

Table A.3. Sub-sample cross-country excess return correlations

1980:07 - 1992:12

Panel A: Stocks

	USA	*Germany*	*Canada*	*Switzerland*	*UK*	*Japan*	*Australia*
USA	1.00						
Germany	0.42	1.00					
Canada	0.76	0.37	1.00				
Switzerland	0.63	0.71	0.57	1.00			
UK	0.67	0.47	0.59	0.63	1.00		
Japan	0.33	0.32	0.32	0.36	0.39	1.00	
Australia	0.48	0.34	0.59	0.46	0.50	0.26	1.00

Panel B: Currencies

	USA	*Germany*	*Canada*	*Switzerland*	*UK*	*Japan*	*Australia*
USA	1.00						
Germany	0.37	1.00					
Canada	0.93	0.39	1.00				
Switzerland	0.27	0.91	0.29	1.00			
UK	0.33	0.64	0.42	0.58	1.00		
Japan	0.45	0.59	0.41	0.59	0.50	1.00	
Australia	0.59	0.24	0.65	0.17	0.34	0.33	1.00

1993:01 - 2004:12

Panel A: Stocks

	USA	*Germany*	*Canada*	*Switzerland*	*UK*	*Japan*	*Australia*
USA	1.00						
Germany	0.72	1.00					
Canada	0.77	0.60	1.00				
Switzerland	0.66	0.70	0.56	1.00			
UK	0.75	0.73	0.63	0.73	1.00		
Japan	0.40	0.35	0.44	0.39	0.36	1.00	
Australia	0.59	0.57	0.57	0.51	0.62	0.50	1.00

Panel B: Currencies

	USA	*Germany*	*Canada*	*Switzerland*	*UK*	*Japan*	*Australia*
USA	1.00						
Germany	0.45	1.00					
Canada	0.82	0.41	1.00				
Switzerland	0.37	0.94	0.25	1.00			
UK	0.69	0.67	0.49	0.57	1.00		
Japan	0.40	0.39	0.32	0.44	0.32	1.00	
Australia	0.50	0.35	0.72	0.13	0.42	0.27	1.00

Table A.3. Continued
2005:01 - 2016:12

Panel A: Stocks

	USA	*Germany*	*Canada*	*Switzerland*	*UK*	*Japan*	*Australia*
USA	1.00						
Germany	0.82	1.00					
Canada	0.76	0.66	1.00				
Switzerland	0.75	0.74	0.58	1.00			
UK	0.83	0.80	0.75	0.73	1.00		
Japan	0.65	0.67	0.56	0.64	0.59	1.00	
Australia	0.77	0.72	0.73	0.71	0.78	0.60	1.00

Panel B: Currencies

	USA	*Germany*	*Canada*	*Switzerland*	*UK*	*Japan*	*Australia*
USA	1.00						
Germany	0.50	1.00					
Canada	0.59	0.56	1.00				
Switzerland	0.47	0.77	0.33	1.00			
UK	0.64	0.64	0.62	0.45	1.00		
Japan	0.72	0.35	0.28	0.51	0.27	1.00	
Australia	0.21	0.65	0.65	0.49	0.45	0.07	1.00

Appendix B

Sub-sample Sharpe Ratio Differences

Table B.1. Differences of Sharpe Ratios between Conditional and Unconditional Hedging Strategies.
The results are based on monthly data.

1980:07 - 1992:12

	USA	*Germany*	*Canada*	*Switzerland*	*UK*	*Japan*	*Australia*
Conditional Unitary vs. Unitary							
(nominal i.r.)							
SR difference	0.0266	0.0387	0.0282	0.0541	0.0388	-0.0193	0.0081
1-tailed p-value:							
SRb - SRa ≤ 0	0.2337	0.1634	0.2127	0.1011	0.1491	0.6593	0.4118
(real i.r.)							
SR difference	0.0371	0.0282	0.0255	0.0499	0.0429	-0.0001	0.0107
1-tailed p-value:							
SRb - SRa ≤ 0	0.1701	0.2229	0.2378	0.1180	0.1390	0.5009	0.3857
Conditional Universal vs. Universal							
(nominal i.r.)							
SR difference	0.0285	0.0211	0.0268	0.0311	0.0241	-0.0056	0.0114
1-tailed p-value:							
SRb - SRa ≤ 0	0.1738	0.2775	0.1947	0.2027	0.2602	0.5583	0.3698
(real i.r.)							
SR difference	0.0327	0.0147	0.0259	0.0252	0.0241	0.0067	0.0106
1-tailed p-value:							
SRb - SRa ≤ 0	0.1525	0.3338	0.2020	0.2480	0.2647	0.4266	0.3768
Conditional Min.Var. vs. Min.Var.							
(nominal i.r.)							
SR difference	0.0365	0.0104	-0.0177	0.0576	0.0145	0.0180	0.0073
1-tailed p-value:							
SRb - SRa ≤ 0	0.2339	0.4226	0.6782	0.1615	0.3627	0.3834	0.4274
(real i.r.)							
SR difference	0.0485	0.0251	-0.0271	0.0503	0.0117	0.0319	0.0029
1-tailed p-value:							
SRb - SRa ≤ 0	0.1619	0.3168	0.7622	0.1855	0.3872	0.2854	0.4706

Table B.1. Continued
1993:01 - 2004:12

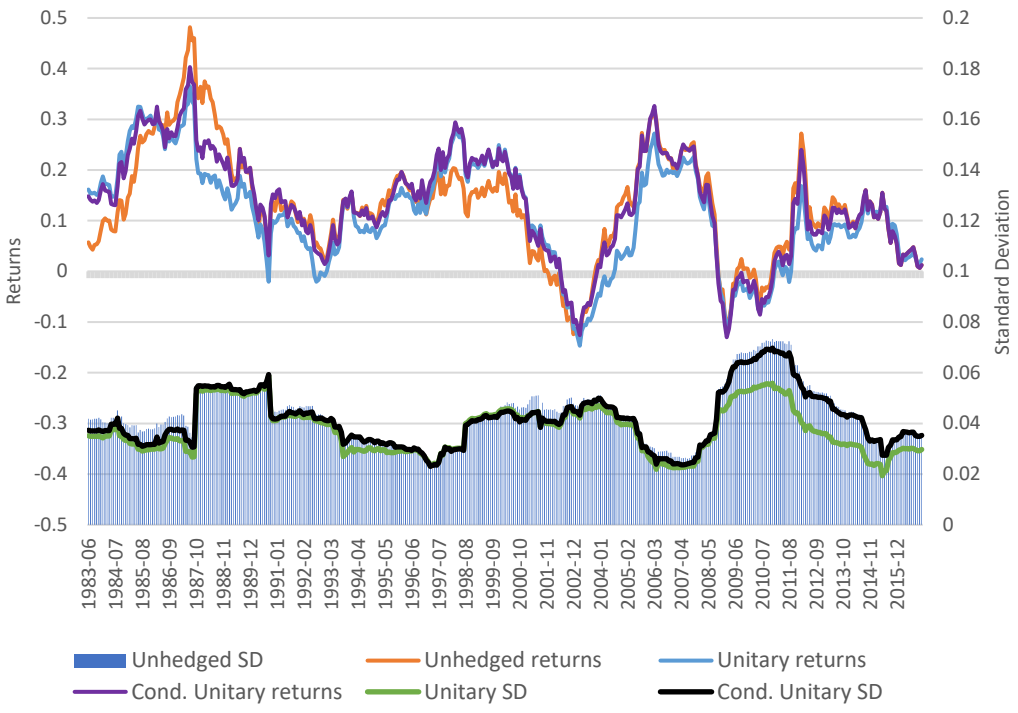
	USA	*Germany*	*Canada*	*Switzerland*	*UK*	*Japan*	*Australia*
Conditional Unitary vs. Unitary							
(nominal i.r.)							
SR difference	0.0524	0.0145	0.0351	0.0061	0.0062	0.0353	0.0233
1-tailed p-value:							
SRb - SRa ≤ 0	0.0877	0.3450	0.1744	0.4328	0.4268	0.2688	0.2685
(real i.r.)							
SR difference	0.0527	0.0141	0.0195	0.0170	-0.0001	0.0344	0.0132
1-tailed p-value:							
SRb - SRa ≤ 0	0.1030	0.3480	0.3025	0.3193	0.5015	0.2627	0.3709
Conditional Universal vs. Universal							
(nominal i.r.)							
SR difference	0.0354	0.0122	0.0224	0.0108	0.0022	0.0525	0.0195
1-tailed p-value:							
SRb - SRa ≤ 0	0.1806	0.3585	0.2772	0.3682	0.4730	0.1259	0.2839
(real i.r.)							
SR difference	0.0361	0.0131	0.0090	0.0177	-0.0016	0.0478	0.0138
1-tailed p-value:							
SRb - SRa ≤ 0	0.1892	0.3480	0.4071	0.2892	0.5197	0.1344	0.3521
Conditional Min.Var. vs. Min.Var.							
(nominal i.r.)							
SR difference	0.0842	0.0251	-0.0190	0.0232	-0.0081	0.0210	0.0004
1-tailed p-value:							
SRb - SRa ≤ 0	0.0923	0.3361	0.6668	0.3740	0.5754	0.3855	0.4958
(real i.r.)							
SR difference	0.0479	0.0026	0.0181	0.0602	0.0094	0.0128	0.0055
1-tailed p-value:							
SRb - SRa ≤ 0	0.2129	0.4807	0.3420	0.1797	0.4065	0.4226	0.4446

Table B.1. Continued
2005:01 - 2016:12

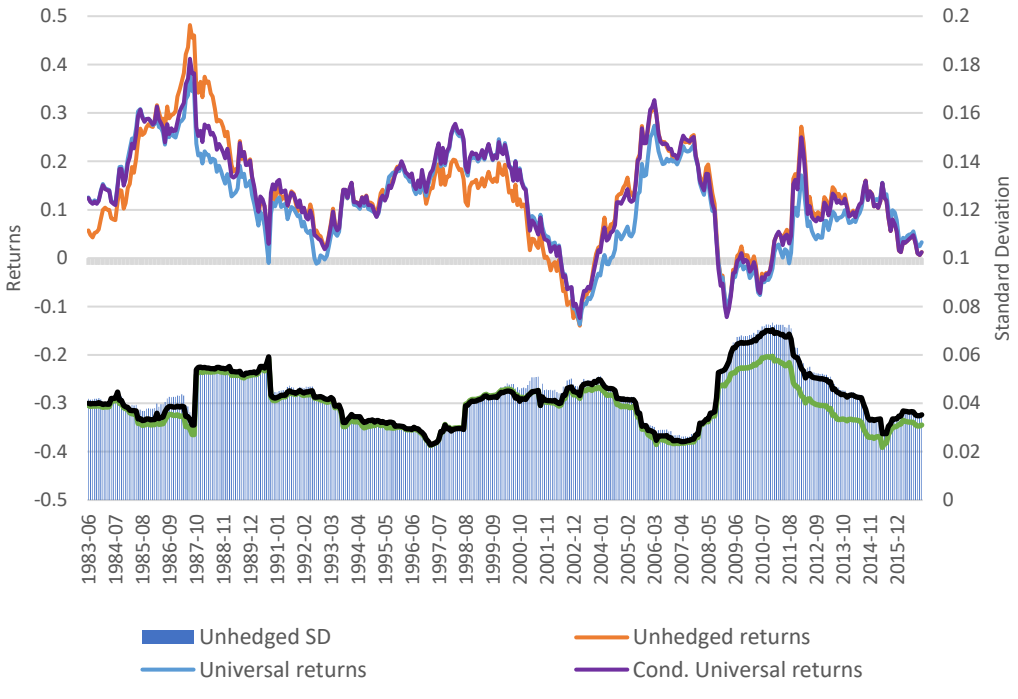
	USA	*Germany*	*Canada*	*Switzerland*	*UK*	*Japan*	*Australia*
Conditional Unitary vs. Unitary							
(nominal i.r.)							
SR difference	-0.0020	0.0155	-0.0004	-0.0057	0.0127	0.0135	0.0000
1-tailed p-value: SRb - SRa ≤ 0	0.5264	0.2784	0.5053	0.5584	0.3234	0.3548	0.5000
(real i.r.)							
SR difference	-0.0133	0.0066	-0.0133	0.0022	0.0143	0.0151	-0.0101
1-tailed p-value: SRb - SRa ≤ 0	0.6608	0.4075	0.6700	0.4737	0.3389	0.3334	0.6540
Conditional Universal vs. Universal							
(nominal i.r.)							
SR difference	-0.0062	0.0133	0.0025	0.0200	0.0027	0.0222	0.0000
1-tailed p-value: SRb - SRa ≤ 0	0.5881	0.3041	0.4652	0.2577	0.4642	0.2415	0.5000
(real i.r.)							
SR difference	-0.0207	0.0003	-0.0144	0.0148	-0.0131	0.0137	-0.0072
1-tailed p-value: SRb - SRa ≤ 0	0.7647	0.4948	0.6953	0.2840	0.6661	0.3263	0.6234
Conditional Min.Var. vs. Min.Var.							
(nominal i.r.)							
SR difference	-0.0396	0.0329	-0.0130	-0.0563	0.0493	-0.0622	0.0017
1-tailed p-value: SRb - SRa ≤ 0	0.6931	0.2888	0.5887	0.7371	0.1593	0.7347	0.4722
(real i.r.)							
SR difference	-0.0548	0.0287	-0.0165	-0.0580	-0.0175	-0.0663	-0.0307
1-tailed p-value: SRb - SRa ≤ 0	0.7533	0.3084	0.6015	0.7566	0.5992	0.7472	0.9032

Appendix C

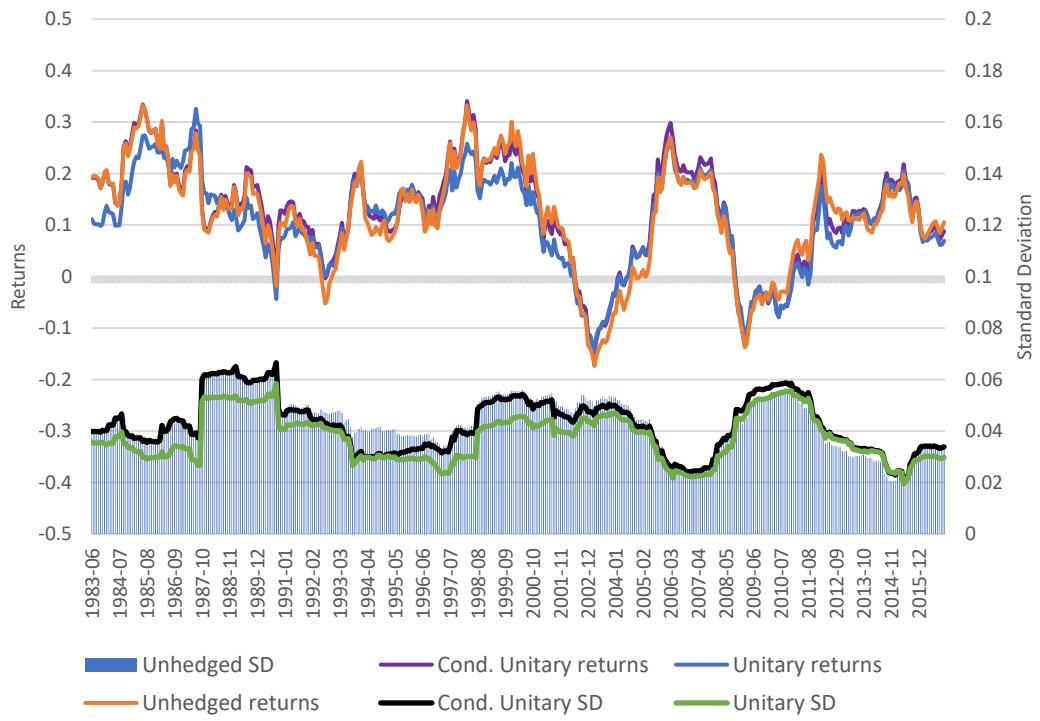
Graph C.1. Performance of the US-based Portfolio: Conditional and Unconditional Unitary Strategy.



Graph C.2. Performance of the US-based Portfolio: Conditional and Unconditional Universal Strategy.



Graph C.3. Performance of Germany-based Portfolio: Connditional and Unconditional Unitary Strategy.



Graph C.4. Performance of Germany-based Portfolio: Conditional and Unconditional Universal Strategy.